Imaging in Swallow Disorder

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Introduction

Normal Swallow Function

Swallowing (deglutition) is a complex, coordinated and sequential process; part voluntary, part involuntary, part motor, part sensory. In health, it requires an intact, integrated neural relay network between the coordinating centres of the central nervous system (brainstem swallow and respiratory centres, the higher cerebral cortex and the lower modulating reflex efferent pathways, e.g. cough), the trigeminal, facial, glossopharyngeal, vagal and hypoglossal cranial nerves and the peripheral motor and autonomic nervous systems that encompass somatic and visceral sensorimotor effects. The motor and autonomic effects are ultimately orchestrated via the striated oropharyngeal/sphincteric and gastro-oesophageal smooth muscle fibres of the enteric nervous system respectively.

Lip closure, healthy dentition, well-functioning temporomandibular joints and balanced neuromuscular masticatory function is necessary. Tongue and palatal movements should be unrestricted. The integrity of highly sensate oral and pharyngeal mucosal surfaces is highly dependent upon normal salivary secretion and content produced by major and minor salivary glands.

Forward peristaltic luminal circular and longitudinal muscle relaxation (opening) and contractility (closing) facilitate propulsion of ingested material from the mouth towards the stomach. The upper (cricopharyngeal) and lower (gastro-oesophageal) sphincters increase antegrade propulsive pressure as well as protect the airway and mucosal surfaces from reflux injuries. The velopharyngeal sphincter prevents nasal regurgitation of food and drink as the bolus exits the oral cavity into pharynx. Maintenance of swallow is inter-dependent upon the respiratory and neurological systems. It may be disturbed by thyroid enlargement, major thoracic vasculature (aortic dissection, aberrant SCA) or cardiac pathology, and by autoimmune and other systemic/connective tissue disorders that impact upon muscle contractility and tissue stiffness.

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Table 15.1 Normal phases of swallow (rapid and precise coordination of numerous muscles and tissues)

1. Oral Phase (preparation, voluntary)	In preparation for swallow, a bolus is chewed, manipulated (mastication) and admixed with saliva.
2. Oral Phase (propulsion, voluntary)	The tongue propels a food bolus towards the oropharynx, beginning the swallow response.
3. Pharyngeal Phase (involuntary)	A bolus passes through the oropharynx into the hypopharynx and oesophagus, while the laryngeal inlet is protected by hyoid elevation and a reflected epiglottis. Initially, the pharyngeal constrictor muscles contract circumferentially as the tongue base contacts the posterior pharyngeal wall, and the soft palate simultaneously elevates to close the nasopharynx and nasal cavity, preventing nasal regurgitation. The vocal folds also adduct, adding further safeguard against aspiration. Following a wave of inhibitory neural impulses, the upper oesophageal sphincter (UOS) temporarily relaxes to allow a bolus into the low resistance of the cervical oesophagus.
4. Oesophageal Phase (involuntary)	The bolus passes anterograde through the oesophagus (passive through gravity and actively via involuntary primary and secondary peristaltic contractions), then enters the stomach upon transient relaxation of the lower oesophageal sphincter (LOS). A wave of inhibitory neural impulses relaxes the oesophageal body and LOS musculature. Progressive circular muscle contraction promotes antegrade passage of the bolus into the stomach.

Normally, there are four defined phases of swallow that are summarised and illustrated in Table 15.1 and Fig. 15.1.

The upper aerodigestive tract shares a common anatomical pathway for both swallowing and respiration; a normal swallow mechanism will prevent tracheal aspiration while breathing is momentarily suspended upon the initiation of swallowing.

Swallow Dysfunction: Epidemiology and Classification

In health, eating and drinking play an important part in physical, social and mental well-being. Across the age spectrum, from neonates and children through to adulthood and the elderly, swallowing or feeding disorders appear relatively common, under reported and under-recognised. The overall incidence and prevalence of such disorders is difficult to quantify, partly due to variability in severity, definitions and classification.

Dysphagia, the medical term for difficulty in swallowing, is classified in ICD-10 under "symptoms and signs" as a condition in its own right. In the broadest sense, it is a subjective difficulty in food, liquid, saliva or medication transiting from the mouth to the stomach. It does not refer to a single specific disease and may be the presenting symptom for a wide variety of pathologies. The pathological process can be singular but, not infrequently, multiple synchronous disorders can result in complex, multi-factorial interrelated pathologies combining to produce symptoms. In their global guidelines and cascades [1], the World Gastroenterology Organisation (WGO) emphasises the important distinction between "oropharyngeal dysphagia," related to the initial phases of swallow, from "oesophageal dysphagia," whereby in the latter the patient reports sticking or a perceived obstruction at a lower thoracic level with solids and/or liquids. This distinction is made clinically on the basis of a careful, considered history in most cases following questions relating to location (high or low), bolus type (solids, liquids, both), pattern (intermittent or progressive) and symptom duration [2]. More specific localisations are not possible through history alone [1]. Dysphagia may or may not be associated with odynophagia (pain on swallow). The context of the presentation, as well as additional clinical findings, helps to determine both severity and the likely aetiology.

Conservative estimates suggest dysphagia impacts 8% of the world's population and almost 100 million people in the developed world [3]. Affecting individuals across all ages, it particularly impacts adversely upon the extremes of age, i.e. infants and the elderly. Feeding problems are seen for between 25% and 45% of normally developing children and up to 80% of children with

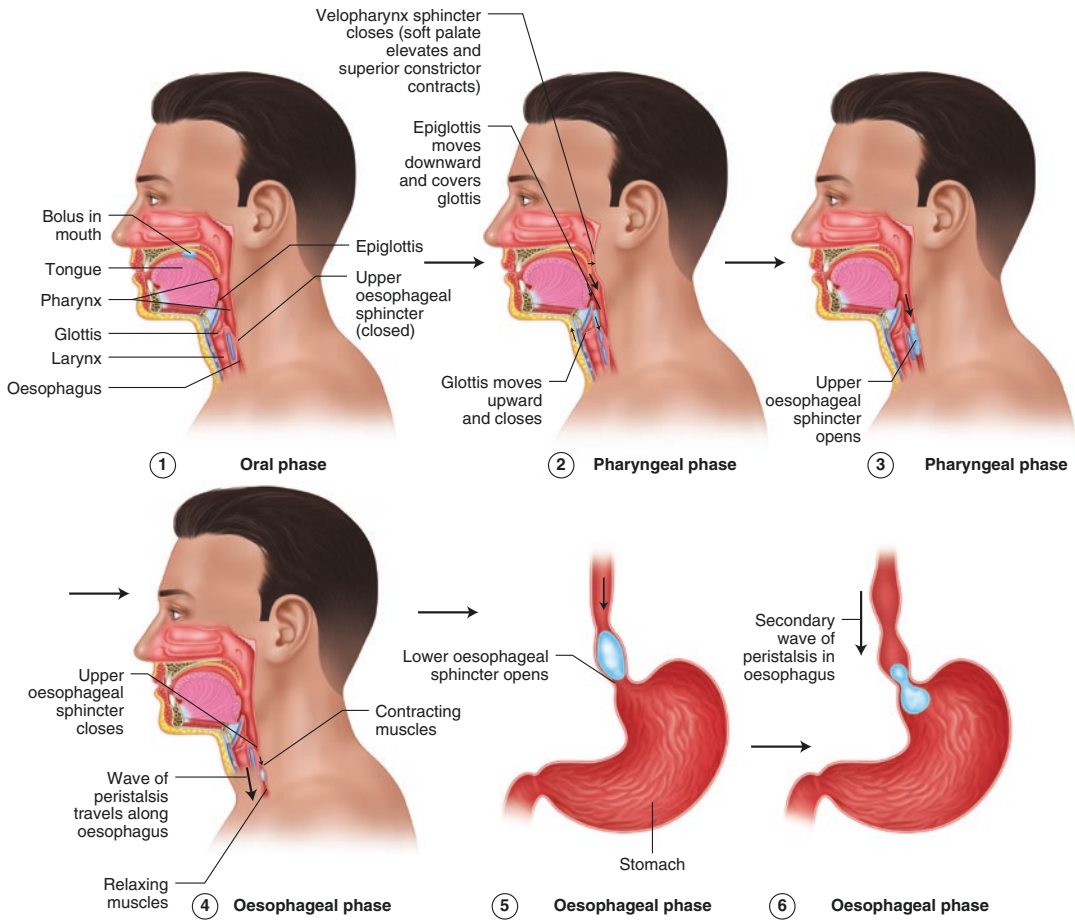


Fig. 15.1 The phases of swallow

developmental delay [4]. 3–10% of children manifest severe consequences as a result of these feeding problems (growth failure, chronic illnesses), with sequelae that continue into adult life. An increase in prevalence relates in part to the improved survival rates for premature births [5]. In the UK, a dysphagia prevalence of 11% is reported in the general population. In specific groups, it is reported in up to 13% of adults over 65, in 51% of elderly institutionalised patients, between 40% and 70% of patients following a stroke, in 60–80% of patients with neurodegenerative conditions and in 60–75% of patients that have undergone radiotherapy for head and neck cancer [1].

Useful classification systems for aetiology, with clinical examples and impact, are provided for "high" oropharyngeal dysphagia" (Table 15.2) and "low" oesophageal dysphagia (Table 15.3).

Clinical Presentation

Both within the community and from more specialist environments, dysphagic individuals will present via a variety of allied healthcare providers. When possible, the diagnostic approach and management should be multidisciplinary in nature and integrated in delivery, thereby drawing upon complementary skill sets and shared expertise of community nursing and allied health care teams, linked with super-specialist hospital-based multidisciplinary teams. Services should be set up and organised with key inputs from Ear nose & throat (ENT), oro-maxillofacial surgery, gastroenterology, upper GI surgery, neurology, speech and swallow therapy, dietetics, paediatrics and medicine for the elderly, supported by rehabilitation teams

and specialist diagnostics, along with radiologists, radiographers, endoscopists and physiologists with dedicated dysphagia expertise and integrated team practice.

An accurate and thorough history should consider a wide aetiological basis, multi-factorial contributors and associated co-morbidities. Enquiry should attempt to separate the perceived type of dysphagia (high versus low) when possible, establish whether liquids (central neurological/neuromuscular), solids (mechanical) or both are problematic, clarify the onset and duration of

Table 15.2 Aetiology in "high" oropharyngeal dysphagia

Type	Cause/effects/conditions	Clinical notes
Neurological: CNS	Brain Trauma (head injury/fall) Cerebro-vascular accident (CVA) Space occupying lesions (primary neoplasm, metastatic disease, etc.) Bulbar palsy, i.e. demyelinating disease (Multiple sclerosis, MS), Progressive degenerative disease [Parkinson's disease (PD), Motor neuron disease (MND), Amyotrophic lateral sclerosis (ALS), Progressive supranuclear palsy (PSP), Multi-system atrophy (MSA)] Dementia Age-related swallow dysfunction (diagnosis of exclusion) Higher centres (stress/emotion—globus pharyngeus)	Motor ± sensory deficit Usually older patients Other neurological deficits Other functional deficits (voice and communication, i.e. dysphonia/dysphasia, breathing difficulties, i.e. stridor/apnoea) Often requirement for gastrostomy/ tracheostomy Globus pharyngeus and age-related swallow dysfunction: diagnoses of exclusion
Neurological: Cranial Nerves	Cranial nerve neuropathy (e.g. MS) Trauma/Iatrogenic, i.e. C-spine/thyroid surgery (Recurrent laryngeal nerve (RLN) injury, Hypoglossal nerve injury in neck dissection Direct effects of invasive malignancy (skull base, neck) on nerves Pressure effects on nerves (mass effect, e.g. post-op neck haematoma and oedema) Cancer treatment effects (radiation-related oedema/neuritis, post-surgery fibrosis) Osteomyelitis of the skull base (malignant otitis externa) Mucosal sensory changes of long-standing Laryngo-pharyngeal reflux (LPR)	Motor ± sensory deficit Cancer direct effects: Head and neck cancers, Lung and Breast cancers (RLN impact and/or metastasis), Other metastatic cancers Lymphomas
Other Neuromuscular/ Autonomic Impairment:	Myasthenia gravis Oculopharyngeal muscular dystrophy Others	Motor ± sensory deficit
Connective Tissue Disorders: Motility Effects on Constrictors and UES (autoimmune/ inflammatory)	Scleroderma CREST syndrome Sarcoid Others	Inflammation, fibrosis and scarring result in reduced muscle compliance Often multi-system, i.e. swallow, voice, respiratory, joints, skin, small vessels
Other Conditions Effecting UES	Zenker's Diverticulum (multiple aetiological theories, including hypertonicity of UES secondary to reflux disease)	

(continued)

Table 15.2 (continued)

Type	Cause/effects/conditions	Clinical notes
Local Causes: Simple/ Mechanical/Obstructive (Intraluminal, Intrinsic, Extrinsic)	Simple/Life-style/Diet	Dental/denture issues TMJ arthritis/dysfunction Mouth ulcers/mucositis/glossitis (dietary vitamin/trace element deficiencies, stress, reflux) Xerostomia (autoimmune sialadenitis, e.g. Sjogren's, post-radiation effects, drug side-effects, etc.) Other URTI and mucosal inflammation – infective (viral, bacterial, fungal, mycobacteria) – autoimmune (pemphigus bulla, etc.) Mucosal colonisation and altered biofilm (oropharyngeal candida) especially in Diabetics, elderly, immunocompromised, reflux, etc.
	Mechanical	E.g. Tracheostomy *in situ* (cuff inflated), thyroid goitre, post-op scarring (all impair larynx excursion)
	Obstructive: Intraluminal	Food bolus (soft, bony, sharp) impaction Accidental/deliberate self-harm (chemical mucosal injury acid, alkali, bleach, etc.), (thermal/smoke and ash injury in fire): oropharyngeal luminal scarring and narrowing
	Obstructive: Intramural (intrinsic origin)	Laryngopharyngeal mucosal oedema and hyperplasia (reflux disease) Zenker's Diverticulum Neoplasm (benign)—palatine and lingual tonsillar lymphoid hyperplasia (reflux) Neoplasm (malignant)—oral cavity, oropharynx, larynx, hypopharynx malignancy
	Obstructive: Extramural (extrinsic origin)	Infective: External benign compressive effect (deep neck space/parapharyngeal abscess) Neoplasm: External benign compressive effect (cervical osteophytes, deep lobe parotid/parapharyngeal tumour, Multi-nodular thyroid goitre, gross cervical lymphadenopathy) Neoplasm: External malignant compressive/invasive effect (Lymphoma, Thyroid cancer invading pharynx/ oesophagus)

symptom development, the course (intermittent, or progressive), pattern and severity of associated problems (coughing/drooling/chest sepsis following aspiration, weight change, hospitalisation, etc.).

Associated symptoms (odynophagia, dysphonia, dyspnoea) should be documented. Full multi-systems medical, surgical and prescribed drug review is essential, as is the quality of life issues through validated questionnaires. Clinical evaluation should include measurement of body mass index (BMI), caliper measurements indicative of malnutrition and obesity indices. A comprehensive head, neck and chest assessment is mandatory. Direct/endoscopic examination of the

Table 15.3 Aetiology in "low" oesophageal dysphagia

Type	Cause/effects/conditions	Clinical notes
Intraluminal	Food bolus/foreign body obstruction	Soft, bony, sharp (acute dysphagia)
Mucosal (Intrinsic)	Gastro-oesophageal reflux disease (GORD) and peptic stricture Oesophageal webs, rings and diverticulae (Plummer-Vinson syndrome) Chemical/thermal oesophageal mucosal injury Radiation injury Infective oesophagitis (herpes simplex, candida albicans) (immunocompromised/ Diabetes/antibiotic/steroid use) Eosinophilic oesophagitis (EoE) (in children and young adult men in particular, dysphagia intermittent/food bolus obstruction) Schatzki ring—benign circumferential smooth narrowing in the distal oesophagus—commonly associated with GORD and EoE Benign and malignant neoplasia (oesophageal adenocarcinoma, SCC)	Stricture formation, fibrosis and partial/ complete stenosis Consider long-term oesophagitis side-effects of ingested pills and drugs (aspirin, other acids) Clinical history (thorough symptom enquiry and systems review, accompanied by appropriately timed endoscopy ± histological confirmation) Often associated with the history of atopy
Intramural (Intrinsic): Neuromuscular/ Connective Tissue Disorders	Achalasia (primary, or associated with neoplasia, Chagas disease) Other major disorders of oesophageal peristalsis (e.g. Distal oesophageal spasm, Jack-hammer oesophagus, absent peristalsis) Other non-specific oesophageal dysmotility	Achalasia (primary)—no normal oesophageal peristalsis and inadequate relaxation of the LOS Pseudoachalasia can be seen in infiltrative diseases of the LOS (e.g. neoplasia), systemic diseases (e.g. sarcoidosis and amyloidosis), or as a complication of gastric banding
Intramural (Extrinsic):	Sliding hiatus hernia (intussusception causing obstruction)	Acute dysphagia with low oesophageal obstruction
Extramural (Extrinsic):	Mediastinal disease (benign or malignant) – Infections (TB, histoplasmosis) – Benign cysts and tumours (thymic, foregut) – Cancers (lung, thymus, retrosternal thyroid/trachea) – Lymphoma Cardiovascular (dilated left atrium, thoracic aortic aneurysm, other congenital vascular anomaly)	Direct compressive or invasive effect on the oesophagus, or via lymphadenopathy
Iatrogenic	Post-anti-reflux surgery (e.g. Nissen's fundoplication, LINX procedure) Post-bariatric surgery (e.g. gastric band/ sleeve gastrectomy) Post-ablative treatments (e.g. stricture formation following radiofrequency ablation therapy in Barrett's oesophagus)	For example, too tight a wrap exerting a mechanical obstruction, likely to be more significant in patients with underlying oesophageal motility disorders Either as a result of the procedure itself or complications, e.g. stricture

mucosal membranes of the oral cavity, oropharynx, larynx, hypopharynx and oesophagus is indicated early in the diagnostic pathway to optimise the most appropriate imaging investigations and additional useful tests.

Diagnostic Tests

A wide range of diagnostic tests are performed in the context of dysphagia to evaluate and exclude likely causes and to define the severity of any

nutritional and metabolic consequences. These are summarised in Tables 15.4, 15.5, 15.6 and 15.7, with short summaries of each test, its relevance, advantages, limitations and contraindications.

Imaging modalities include fluoroscopic, luminal endoscopic and cross-sectional radiological studies, and the information obtained is often complementary in aiding the treating clinicians. Up-to-date knowledge is vital. Where a good evidence-base is lacking for clinical utility of a specific modality, a clear articulation and communication of the diagnostic question posed is paramount on any imaging or physiological test requests, accompanied by an agreed, resource-optimised dysphagia imaging strategy and hierarchy for tests that is supported by the whole multidisciplinary team.

Acute and Elective Clinical Presentation in Management of Dysphagia

In hospitals, patients with dysphagia may present acutely or via semi-elective care pathways across a variety of specialist services. They may be referred directly with primary swallow complaint or indirectly as unrecognised but linked pathological complications such as coughing, choking, chest sepsis, speech disturbance, upper airway compromise and malnutrition. In the community, they may present to multiple health care professionals in variable locations, including general practitioners (GPs), pharmacists, dentists, community speech and language therapists (SLTs), nursing homes, home carers and palliative care services.

Often elective dysphagia referrals to specialist services are in the context of urgent suspected cancer care pathways (red flag for Head and Neck [H and N] and Upper GI services). However, in reality, there is a real difficulty in unravelling the complexities given the wide differential, often coexisting aetiologies and complicating symptoms. This potentially generates a convoluted and resource-heavy care pathway. A plethora of clinical and imaging tests may be required to exclude cancer without definitively correcting or managing non-neoplastic swallowing issues. Consequently, repeat clinical attenders fall between separate services and across hospitals operating in geographically isolated and poorly networked silos.

At the time of writing, there is limited national and systematic data available on the true number of dysphagic patients that present through the emergency care pathway (i.e. where dysphagia issues are directly or indirectly recognised and coded, linked to cause for hospital admission). Often, these patients are elderly with multiple comorbidities (COPD, heart failure, diabetic complications, etc.) that can distract the medical focus and delay assessments. Frequently, this group of vulnerable patients suffer and struggle to articulate underlying symptoms due to cogni-

Table 15.4 Non-imaging baseline diagnostic tests

Test	Test specifics	Indications/limitations Advantages/disadvantages	Notes: System costs, evidence base and utility
Non-Imaging Baseline Diagnostic Tests (considering dysphagia aetiology and homeostatic impact)			
Blood Tests	FBC, U and E, Liver function tests, Bone profile, Inflammatory markers, Serology, Fe/trace elements/vitamin levels, Auto-antibodies, Thyroid function tests	Hydration, Nutritional status/ deficiencies, Metabolic/hormonal disturbance,	Multiple test battery. Invasive but ready community access. Targeted utility in high-risk groups, i.e. elderly.
Bedside Swallow Test [6–8]	3 oz (qualitative) or 100 ml (qualitative and quantitative) water swallow test, performed by trained nursing, SLT and medical staff. Look for inability, coughing, choking, hoarse/wet voice within 1 min.	Quick, simple, non-invasive, minimal equipment. In Neuro and H and N population, good sensitivity (>95%) for detecting aspiration versus VFS [6] & FEES [7] but specificity not so good (<50%). Need other tests to discern pathophysiology.	Cheap. Useful as first-line assessment and/ or monitoring change over time following the intervention. Low specificity limits its utility as a screening tool in dysphagia.

Table 15.5 Endoscopic imaging in swallow disorder

Test	Test specifics	Indications/limitations Advantages/disadvantages	Notes: System costs, evidence base and utility
Endoscopic Imaging ± Tissue Biopsies for Histology			
Flexible Nasal Endoscopy (FNE)	Fibreoptic/chip-tip trans-nasal endoscopic evaluation of larynx & pharynx (with Local Anaesthetic, LA)	Advantages: Useful to screen for anatomical asymmetry and mucosal irregularities within nasal cavity, pharynx and larynx. Generally well tolerated with very few risks associated. Disadvantages: Requirement for technical skill, standardised assessment, endoscopes/camera stack, endoscope sterilisation. Biopsy difficult unless modified endoscopes and cancer staging capabilities limited with patient awake.	Good for first line screening but sensitivity and specificity are limited for disease screening. Presently triaging role, allowing distinction between functional and organic causes for dysphagia, dysphonia and gross survey of upper aerodigestive tract lumen and mucosa. The emergence of disposable single-use endoscopes promise a reduction in costs, wider availability and adoption
Trans-Nasal Oesophagoscopy (TNO) [9]	Fibreoptic/chip-tip trans-nasal endoscopic evaluation of larynx, pharynx and oesophagus (with LA)	Advantages: Useful to screen for asymmetry and mucosal irregularities within nasal cavity, pharynx, larynx and oesophagus. Generally well tolerated with very few risks associated. Biopsy capabilities. Disadvantages: Requirement for technical skill, standardised assessment, endoscopes/camera stack, endoscope sterilisation.	Potential role for "one-stop" screening in dysphagia, avoiding costs of repeat hospital visits and possible sedation/GA. Limited uptake and availability due to up-front equipment cost, and traditional service structure. Emergence of disposable single-use endoscopes promising TNO training courses more widespread
Functional Endoscopic Evaluation of Swallow (FEES) ± Sensory Testing (FEES-ST) [10–13]	Fibreoptic/chip-tip trans-nasal endoscopic evaluation of larynx & pharynx (without LA). Further allows dynamic assessment of the pharyngeal stage of swallow, aspiration risk and swallow therapy strategies/biofeedback. Patients observed swallowing dyed food and drink. Post swallow residue (location/amount) and airway safety (larynx penetration) assessed. Sensory testing allows objective measurement of laryngeal adductor reflex (impaired in a variety of disorders including LPR)	Advantages: Bedside/OPD assessment therefore a useful alternative to VFS for patients with limited mobility or where VFS service not available. Most ENT clinics already equipped with necessary endoscopes and camera stacks. Like VFS, continuing definition, development and refinement (standardisation) of evaluation protocols and necessary MDT training and skills competencies. Disadvantages: SLT and ENT services presently organised independently and limited by necessary professional manpower and expert competencies Does not allow oral or oesophageal stage assessment	Combined SLT-ENT multidisciplinary clinics require business modelling. Competencies for undertaking and reporting FEES is outlined in the RCSLT FEES policy [13]
Oesophago-Gastro-Duodenoscopy (OGD)	Fibreoptic/chip-tip trans-oral endoscopic evaluation (with sedation/GA) of oesophagus, stomach, duodenum ± tissue biopsies for histology	Advantages: high sensitivity and specificity for detecting abnormalities, therapeutic options available. Readily accessible in secondary care services Disadvantages: Often requires separate outpatient attendance, may require sedation/GA, relatively invasive	JAG (Joint Advisory Group) for Upper GI Endoscopy sets specific multidisciplinary (mainly gastroenterology, upper GI surgery and nurse endoscopists) criteria for achieving accreditation in Upper GI Endoscopy, including training in recognised units and attending JAG approved courses.

Table 15.5 (continued)

Test	Test specifics	Indications/limitations Advantages/disadvantages	Notes: System costs, evidence base and utility
Endoscopic Imaging ± Tissue Biopsies for Histology			
Rigid/Direct Pharyngo-Oesophagoscopy	Rigid trans-oral intubation and Hopkins glass rod endoscopic evaluation of pharynx and oesophagus ± foreign body/impacted food bolus retrieval ± biopsy ± other therapeutic intervention (i.e. CARES) (with GA)	Advantages: allow biopsy and therapeutic intervention (e.g. laser/balloon dilatation of oesophageal stricture) Disadvantages: cost of GA, hospital stay and additional theatre equipment	Limitations of rigid pharyngo-oesophagoscopy circumvented for evolving minimally invasive therapeutic options (ENT and Upper GI surgeons operating together, e.g. Combined Anterograde Retrograde Endoscopic Surgery, CARES) for hypopharynx strictures

Table 15.6 Radiological imaging in swallow disorder

Test	Test specifics	Indications/limitations Advantages/disadvantages	Notes: System costs, evidence base and utility
Radiological Tests			
CXR	X-rays, mobile/fixed	Diagnose aspiration pneumonia Diagnose cardiomegaly/retrosternal thyroid goitre, mediastinal lymph node enlargement, chest malignancy Disadvantage: ionising radiation	Cheap and accessible Provides information on some organic neck/thoracic aetiologies and airway complications.
Lateral Soft Tissue Neck	X-rays, fixed	Adenotonsillar hyperplasia (children) Deep neck space infection (DNSI)/retro/parapharyngeal abscess Foreign body/food bolus obstruction Disadvantage: ionising radiation	Cheap and accessible. Limited information but can be useful first-line investigation.
Barium Swallow	X-rays, Barium drink for contrast ± barium-soaked solid bolus ingestion. AP, oblique, lateral, sitting, lying, head down, marshmallow, bread/weetabix ± water siphon test Digital stills/short video film to limit radiation exposure	Advantage: Gross anatomical detail on luminal integrity (narrowing/enlargement), as well as some functional detail on swallow mechanism. Disadvantages: ionising radiation. Standardised protocols but variability remains between units, protocol often adapted to clinical question and presentation [14]. Contrast often not palatable, and may cause pneumonitis if aspirated or mediastinitis if leaks from a pharynx/oesophageal lumen perforation. Significant inter-observer reporter variation [15] Contraindications: suspected or confirmed pregnancy, barium allergy, recent oesophageal trauma or risk of oesophageal perforation/fistula.	Widely performed, accessible, first-line test but not sensitive or specific for early-stage mucosal disease (hospital-based). Requires specialist radiologist/radiographer with interest in swallow dysfunction. Good to demonstrate Zenkers/oesophageal diverticulae, webs/strictures & stenosis, oesophageal motility disorders, achalasia, intrinsic/extrinsic neoplasia (early stage may be missed). Hardware cost and maintenance, manpower heavy, digital data-set archiving (PACS system expense).

(continued)

Table 15.6 (continued)

Test	Test specifics	Indications/limitations Advantages/disadvantages	Notes: System costs, evidence base and utility
Radiological Tests			
Video Fluoroscopy Swallow (VFS) (Modified Barium Swallow, MBS) [16–18]	X-rays, water-soluble contrast agents Dynamic, real-time capture of all four physiological stages in swallow, allowing anatomical/structural detail with function assessment. Range of fluid & food textures mixed with contrast. Joint MDT service (radiologist with interest in swallow dysfunction, SLT ± ENT). Digital stills/short video film to limit radiation exposure	H&N/Neurological/Neuromuscular patients, i.e. oral and pharyngeal phase issues (complex H and N pre/post chemoradiation or surgery, e.g. LASER resection, laryngectomy) Sequence, timing and synchronicity of swallow stages (tissue & organ interaction) observed. Allows for assessment of swallowing physiology, including airway penetration/aspiration related to varying consistencies of food/drink. Allows testing of different posture and swallow therapy strategies where dysfunction or abnormality is noted. Disadvantages: ionising radiation, MDT and equipment expense. Evidence for significant intra/inter-observer variability in reporting [19] Contraindications: Decreased Glasgow coma scale (GCS), uncooperative patient, medical instability, pregnancy, contrast allergy	Hospital-based fluoroscopy suite. Hardware and maintenance costs, MDT manpower heavy, digital data-set archiving (PACS). Requires specialist radiologist/radiographer support with interest in swallow dysfunction, working closely with SLT/ENT/Neuro. Need for standardised test protocols, equipment, analysis, reporting and training requirements. (American College of Radiologists [20]) (Royal College of Speech and Language Therapists [21]) Developments for more objective measurements in reporting [22]
Ultrasound Scan Neck	Transverse, oblique images, colour and power Doppler imaging. Fine Needle Aspiration (FNA)	Portable assessment of soft tissue in the neck mainly for the assessment of lymph nodes and their vascularity. Anatomical information and gross definition of the soft tissues in the neck. US+FNA allows local nodal (N) staging when CT and MRI are equivocal in cancer	Portability/ready GP access and community availability result in incidental pathology pick-up (e.g. asymptomatic thyroid nodules) May illustrate the mass effect of pathology on tongue, pharynx, oesophagus, e.g. UADT/thyroid tumour, abscess.
CT Head, Neck Chest, Abdomen	Volumetric acquisition +IV contrast administration.	Good macro imaging detail with tissue/iv contrast. Good to illustrate intrinsic and extrinsic causes for high and low dysphagia related to tumour mass effect or other cause May reveal ingested foreign body Faster, higher resolution, finer cut systems with 3D reconstruction. Disadvantages: Cost, ionising radiation exposure +++ Not sensitive for early mucosal disease. Role in primary tumour (T) staging (inferior accuracy to MRI), N (inferior accuracy to PET/CT) staging but mainly metastatic (M) staging in cancer	Hospital-based services. Expensive hardware and software through modern PACS image storage and retrieval. Shorter acquisition time than MRI. Widely available but extreme demand and pressure on services, particularly related to acute/emergency/trauma and cancer services activity.

Table 15.6 (continued)

Test	Test specifics	Indications/limitations Advantages/disadvantages	Notes: System costs, evidence base and utility
Radiological Tests			
MRI Brain, Head and Neck, Spine	Axial, sagittal T2, coronal STIR, Axial T1 fat saturated pre- and post-contrast and Diffusion-Weighted (DW) imaging. Dynamic, real-time MRI assessment of Swallow [23–25]	Better soft tissue resolution than CT with iv contrast/DW-MRI options Differentiating between central and peripheral causes of symptoms. Defining alterations in anatomical relationships, useful in defining dysphagia multi-causality, i.e. MS and cervical osteophytes. Assessment of primary SCC providing correct T staging, information on resectability and radiotherapy planning. DWI: improves lesion conspicuity, characterisation, monitoring. Complementary role in assessing the irradiated neck. Fewer problems with dental artefacts. Disadvantages: More false positives in the mandible, low sensitivity for calcifications, motion artefacts in the infrahyoid neck and chemical shift artefacts resulting in missed cortical lesions.	Hospital-based services. Expensive hardware and software through modern PACS image storage and retrieval Longer acquisition time than CT. Increased availability but remains more difficult to access and expensive than CT. High demand and pressure on services, particularly related to acute/emergency and cancer services activity Dynamic MRI assessment of swallow is an emerging and promising tool very much limited to a research setting presently (larger and faster data handling requirements for hardware and software)
PET-CT	FDG-PET/CT	Inflammation, i.e. connective tissue disease and post-cricoid myositis and malignancy Similar sensitivity to CT in T staging of primary SCC, main role in M staging of primary SCC, detection of primary in carcinoma of unknown origin and recurrent SCC. May miss small lesions or lesions with low metabolism (e.g. minor salivary gland neoplasms)	Limited availability requiring combination of nuclear medicine and radiology resources. Provision at regional level, increases expense and limits access further. FDG is not tumour-specific, requiring specialist interpretation with caution. In the context of cancer, false positive findings are common (increased FDG uptake and SUV without malignancy), and may be related to physiological activity (metabolic uptake from tongue and vocal cords), thyroid gland metabolism, benign disease (acute or chronic inflammation, including reflux, autoimmune and granulomatous), or inflammation following radiotherapy, trauma, or surgery.

Table 15.7 Specialist ENT and upper GI physiological sensory tests

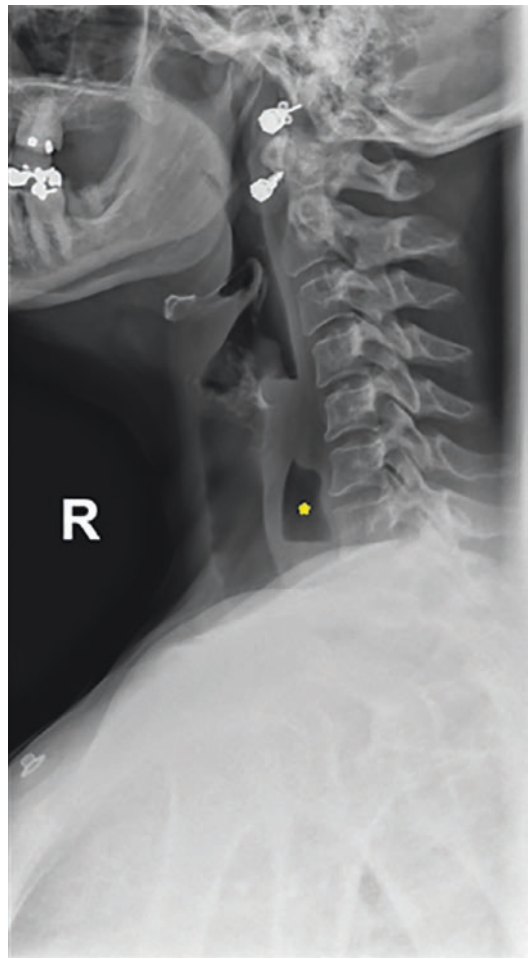
Test	Test specifics	Indications/limitations Advantages/disadvantages	Notes: System costs, evidence base and utility
Specialist ENT and Upper GI Physiology Imaging/Tests			
Wireless Capsule pH monitoring 48–96 h (Bravo) [26, 27]	Wireless pH capsule placed endoscopically in the distal oesophagus mucosal wall. Spontaneously detaches within 14 days.	Advantages: can measure oesophageal pH for up to 96 h. Useful in patients otherwise intolerant of conventional pH monitoring, i.e. nasal catheter Disadvantages: requirement for OGD to place capsule, expensive, early capsule detachment, occasionally does not dislodge and requires OGD removal	Hospital-based service. Currently, only available in a handful of centres in London and around the UK, partly inhibited by cost and requirement for specialists, but becoming increasingly available
High-Resolution Oesophageal manometry [28, 29]	Nasogastric catheter with multiple circumferential sensors—measures pressure simultaneously along oesophageal body and across UOS and LOS	Advantages: High degree of sensitivity and specificity for detecting and differentiating oesophageal motility disorders Disadvantages: Equipment expense, need for professional expertise	Hospital-based service Motility services available in most tertiary care hospitals, although regional provision of services varies depending on local expertise
Ambulatory 24 h pH / ± Impedance Manometry [30, 31]	Thin nasogastric catheter with one or more pH sensors placed at defined distances in relation to the GOJ. Impedance detects chemical and physical composition of refluxate (e.g. acidic/non-acidic and whether liquid/gas/mixed) based on electrical resistance and current flow between electrodes	Advantages: Current gold standard, allows symptom correlation and detection of reflux independent of pH value. Can distinguish anterograde flow and retrograde (reflux), as well as the height of refluxate. Disadvantages: Relatively invasive, requirement for NG catheter placement for 24 h. Use of impedance requires suitable expertise. The tip of the catheter moves with breathing.	Hospital-based service Currently, only available in a handful of centres in London and around the UK, partly inhibited by cost and requirement for specialists, but becoming increasingly available
Restech Pharyngeal Dx-pH Measurement System [32–34]	Aerosolised and liquid pH measurement using fine 1 mm catheter probe. Tip placed via nose to sit at level of uvula (oropharynx)	Advantages: less invasive than traditional methods for pH monitoring Disadvantages: newer diagnostic modality so lack of adequate evidence base, limited correlation with other diagnostic methods to date	Not enough evidence to support routine clinical use; therefore, currently mainly clinical research
Sputum Pepsin/ Bile Acid Immuno-assay [35]	Detection of salivary pepsin in sputum samples by indirect sandwich ELISA (Peptest™)	Advantages: Cheap, quick, non-invasive and easy to use. Disadvantages: Lack of evidence on treatment outcomes, limited data on use in patients with atypical symptoms	2015 NICE Review: Limited quantity and relevance of published evidence on Peptest diagnostic accuracy in GORD and LPR, no published studies in children [36]. More recent multi-centre data suggesting potential for primary care use [37] and LPR disease screening [38].

tive and communicative difficulties. It is increasingly clear that sarcopenia secondary to ageing and malnutrition leads to premature declining health in the elderly.

In the following section, both acutely and electively, a selection of adult cases are reviewed, covering a variety of clinical presentations for dysphagia. These seek to illustrate the role imaging can play in aiding assessment and management, with an introduction to more complex considerations around imaging strategies for swallow dysfunction and rehabilitation.

Clinical Cases

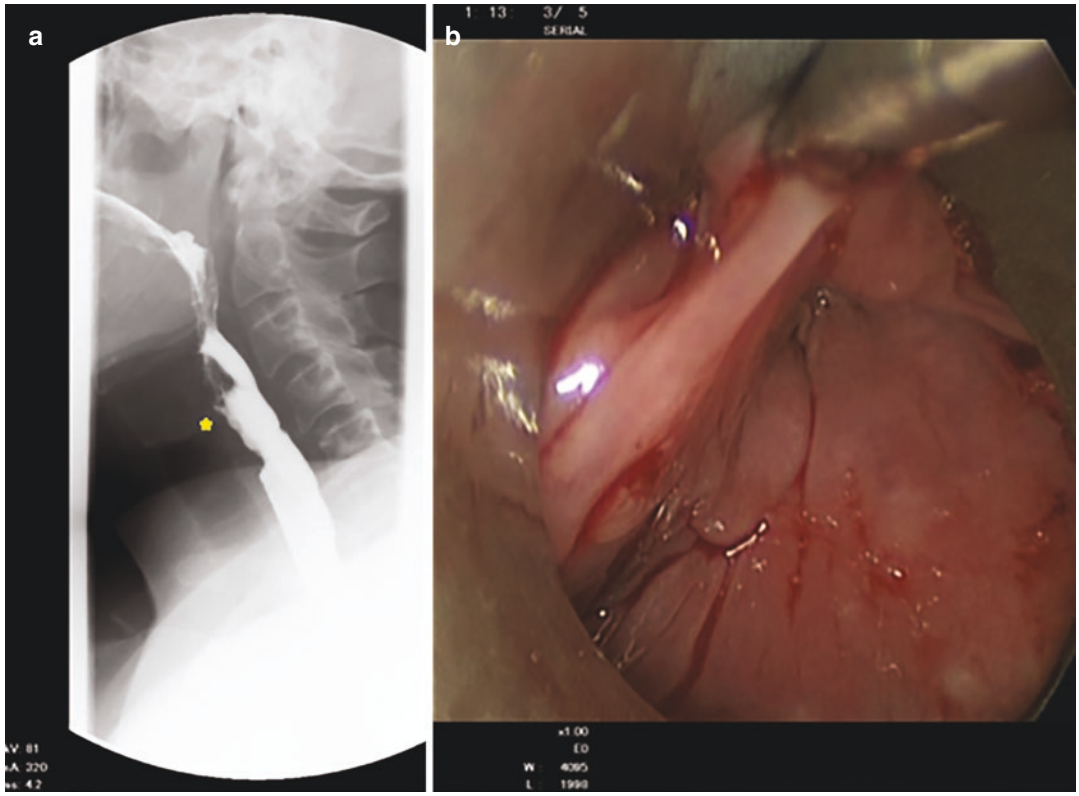
Case 1



A 52-year-old female admitted acutely from A&E with meat bolus obstruction. Lateral soft tissue cervical radiograph: Air in a dilated proximal oesophagus with an air-fluid level due to an obstructing food bolus. No retropharyngeal air. Despite conservative measures, the bolus failed to advance, and the patient required direct rigid pharyngo-oesophagoscopy to dislodge the bolus distally into the stomach. Patient was subsequently discharged well without perforation

Key Learning Point: A lateral soft tissue neck image may be all that is required to make a diagnosis of foreign body/food bolus obstruction prior to theatre.

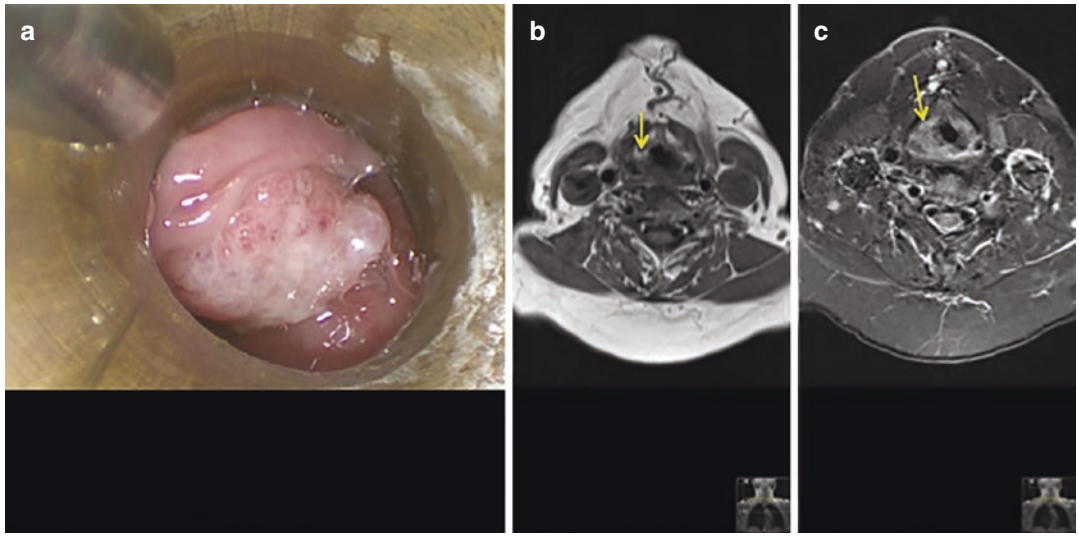
Case 2



A 50-year-old female smoker and heavy drinker with a family history of oesophageal cancer. As the patient reported a long-standing history of GORD symptoms, she was referred to an urgent suspected Upper GI cancer pathway. Unable to tolerate an OGD under sedation, she underwent a barium swallow which reported a mucosal irregularity anteriorly in the post-cricoid oesophagus of uncertain significance. Onward referral to the ENT (H and N) cancer pathway was followed by rigid direct pharyngoscopy under GA. This confirmed redundant, oedematous hyperplastic mucosa in the post-cricoid and inter-arytenoid area, consistent with LPR without a tumour. Imaging: (**a**) Ba Swallow: Anterior hypopharynx irregularity at C6 level suggests focal mucosal oedema or an occult lesion. This imaging was unable to exclude an early cancer necessitating (**b**): direct endoscopic visualisation (Hopkins 0 degree rigid endoscope) under GA to exclude malignancy and facilitate biopsy as required. Redundant hyperplastic and oedematous mucosa of the post-cricoid hypopharynx is lifted endoscopically with laryngeal microforceps

Key Learning Point: The post-cricoid hypopharynx is often over-called on barium swallow studies suggesting swelling and surface irregularity. It is not uncommon for reflux to result in local oedema and mucosal hyperplasia, over interpreted as suspicious for malignancy. Often, direct endoscopic visualisation is required with rigid instrumentation to inspect this area well.

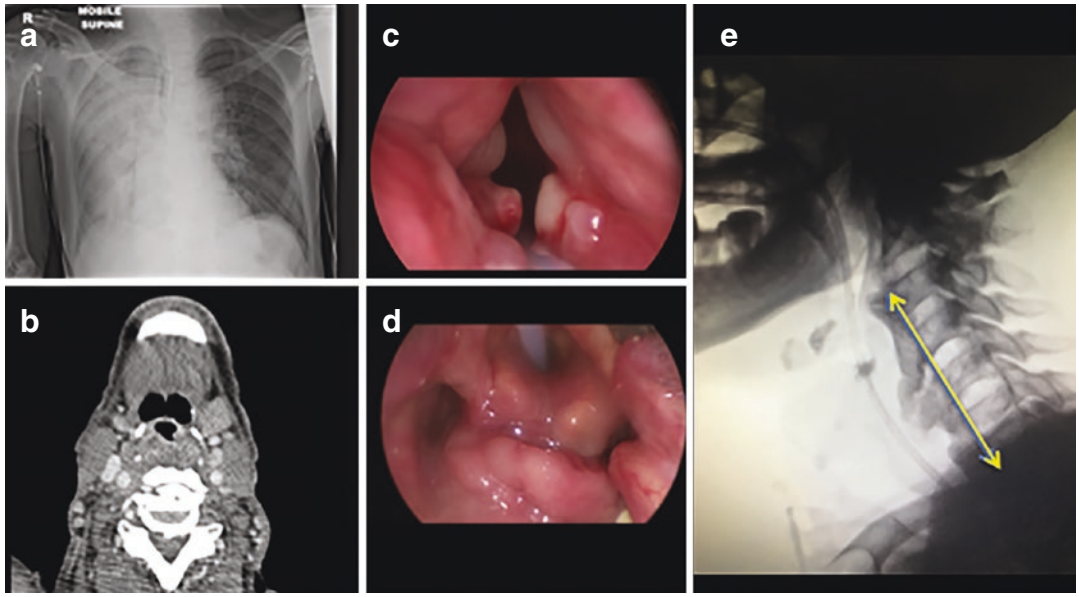
Case 3



A 78-year-old female presenting with "red flag" dysphagia was referred urgently via an upper GI cancer pathway for endoscopic examination. No oesophageal pathology was visualised at OGD (under sedation) but asymmetry was apparent at the pharyngeal level. This prompted urgent referral to the ENT (Head and Neck) cancer pathway, who arranged direct rigid pharyngoscopy and biopsy (under GA) of a right hypopharyngeal mucosal lesion, utilising a rigid 0^0 Hopkins rod endoscope. (**a**) Direct pharyngoscopy and biopsy confirmed an SCC arising amongst squamo-proliferative dysplasia. (**b**) and (**c**) Axial T1W and T2W STIR MR images show a 2 cm right piriform sinus tumour with extension to arytenoid mucosa—radiologically staged at T2N0

Key Learning Point: Hypopharyngeal malignancy can present late with symptoms masked by coexisting laryngopharyngeal reflux. The easily effaced piriform fossa requires direct visualisation to exclude a malignant lesion, and locoregional tumour staging is complemented with MRI use. The scan should be performed pre-biopsy to avoid over-staging from traumatic oedema.

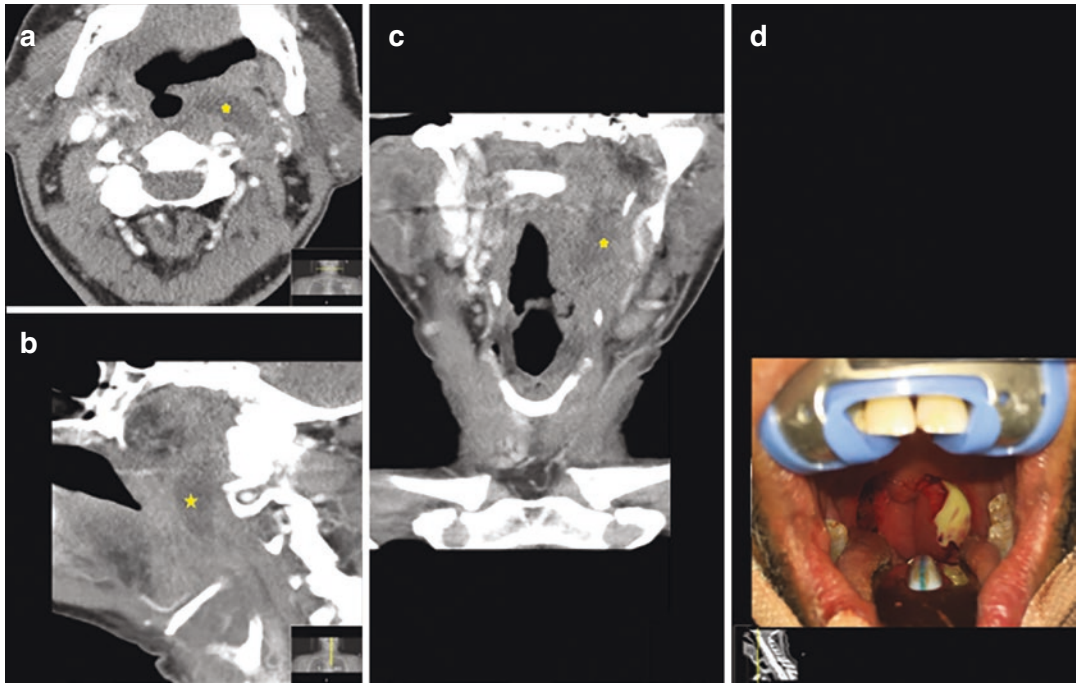
Case 4



A 92-year-old male was admitted emergently under ENT with stridor, shortness of breath and a 24-month history of progressive dysphagia plus non-specific reflux symptoms. (**a**) Chest radiograph confirms bilateral consolidation (likely aspiration pneumonia in the contest of reflux), most extensive throughout the right lung. Flexible nasoendoscopy showed oedematous, symmetrically enlarged arytenoid mucosa prolapsing into the glottis. A biopsy under GA that had been performed elsewhere 3 months earlier (based on a similar presentation) showed no malignancy. (**b**) Axial enhanced CT neck was acquired, demonstrating right supraglottic asymmetry with suspected inflammatory changes alone. The patient required an emergency endotracheal tube (ETT) intubation and ITU admission prior to a repeat CT neck and chest showing non-specific circumferential soft tissue thickening (C4 to T1) surrounding a nasogastric tube (NGT) and bilateral lung consolidation. Large flowing anterior vertebral "block-like" osteophytes (C3 to T1) were noted in keeping with diffuse idiopathic skeletal hyperostosis (DISH). Rigid endoscopy was then performed under GA. Rigid 0^0 Hopkins rod endoscopic view confirms extensive supraglottic, arytenoid and glottic granulations and oedema (**c**), as well as posterior pharyngeal wall swelling secondary to redundant mucosa overlying osteophytic bony projections (**d**). Through trans-oral CO_2 LASER hypopharyngoplasty the redundant mucosa was excised with a temporary covering surgical tracheostomy. A gastrostomy was required for 3 months of enteral feeding before VFS confirmed a safe swallow and resumption of oral intake. (**e**) Lateral soft tissue neck image from a VFS (2 weeks post-op) demonstrates an NGT and tracheostomy ***in situ*** with posterior indentation of pharynx by DISH osteophytes (age, reflux disease, osteophytes and a tracheostomy tube all impacted adversely upon swallowing). A repeat VFS was performed prior to tracheostomy decannulation, gastrostomy removal and ongoing maintenance anti-reflux medical treatment

Key Learning Point: A combination of plain film plus radiological and endoscopic investigations guide appropriate acute and subsequent rehabilitative care in complex dysphagia. Repeat acute presentations and hospitalisation following aspiration is common in elderly patients with multifactorial aetiology for their dysphagia.

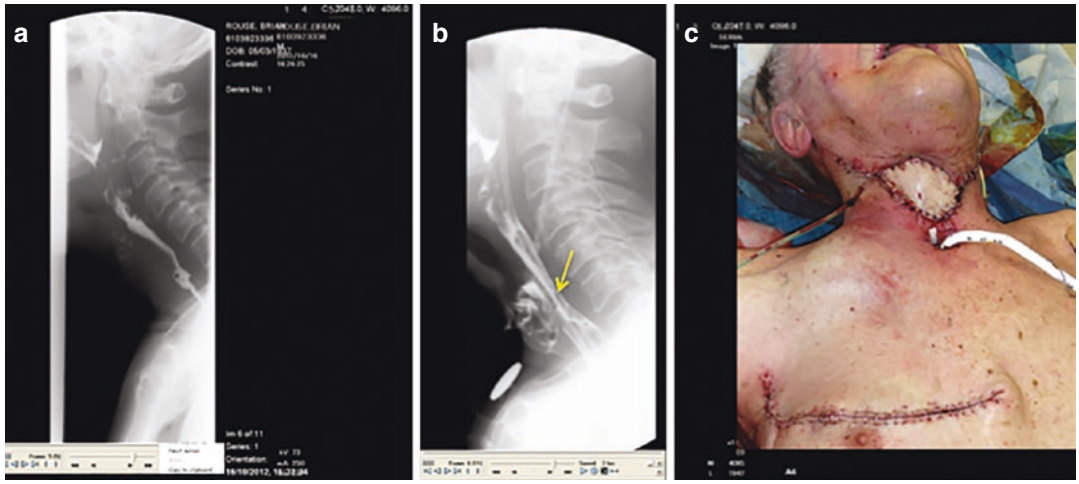
Case 5



A sixty-three-year-old male was admitted acutely with sore throat and odynophagia, despite 1 week's course of oral antibiotics. Clinical examination confirmed fullness in the left lateral neck, and flexible nasendoscopy confirmed a left oro-hypopharyngeal swelling suspicious for a deep neck space infection (DNSI). A contrast CT scan confirmed a left parapharyngeal space abscess which facilitated surgical planning and an optimal approach to drainage (tonsillectomy and trans-oral drainage via constrictor muscles avoided an external neck incision and scar). The patient recovered promptly with intravenous antibiotics and improved swallowing. Contrast-enhanced CT Images (**a**) axial, (**b**) sagittal and (**c**) coronal demonstrated a fluid attenuation (HU-30) left parapharyngeal space collection with enhancing wall consistent with an abscess, extending from C2 to the C4 vertebrae craniocaudally (yellow star). Associated inflammation resulted in midline pharyngeal shift without airway compromise. No retropharyngeal or carotid sheath extension was identified. (**d**) Intraoperative image of Trans-oral drainage of the abscess, with pus expressed through the superior constrictor musculature following tonsillectomy and blunt muscle penetration

Key Learning Point: Acute infective episodes of the UADT mucosa, dentition and palatine tonsils may result in DNSI and abscess development. CT imaging with contrast helps delineate the extent of an abscess and plan an optimal approach to drainage, facilitating a speedier recovery with early hospital discharge.

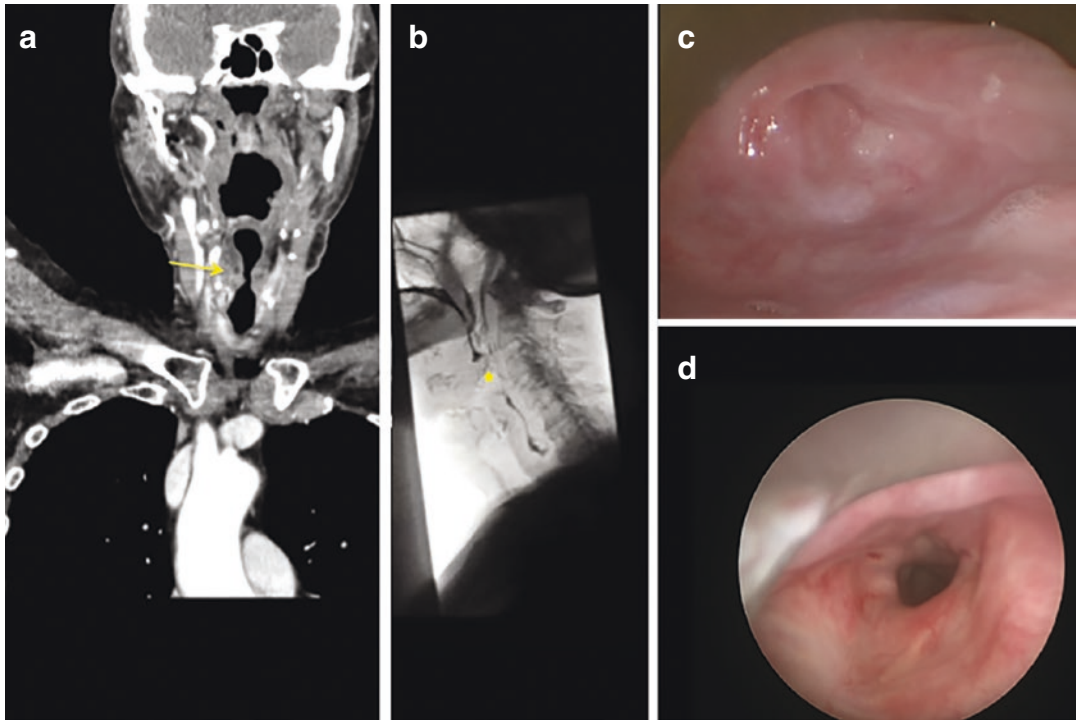
Case 6



A 75-year-old male with HNSCC required salvage laryngectomy and primary closure of neopharynx for residual disease after external beam radiotherapy. Gastrografin contrast swallow: (**a**) 10 days; and (**b**) 6 weeks after surgery illustrated a relatively low pharyngo-cutaneous fistula, in keeping with wound dehiscence, where contrast extravasation (yellow arrow) reached the skin surface anteriorly. (**c**) Delayed successful surgical fistula closure with right pectoralis major musculo-cutaneous flap. The patient later resumed oral intake and avoided gastrostomy tube dependence for nutrition

Key Learning Point: Post-irradiation salvage laryngectomies are associated with poor wound healing and high rates of pharyngo-cutaneous fistula. Resection should be routinely planned with consideration for vascularised tissue transfer into the cervical region, either using a pedicle flap or a free tissue transfer. Serial water-soluble contrast swallow studies can help guide swallow progress and management in the post-operative period.

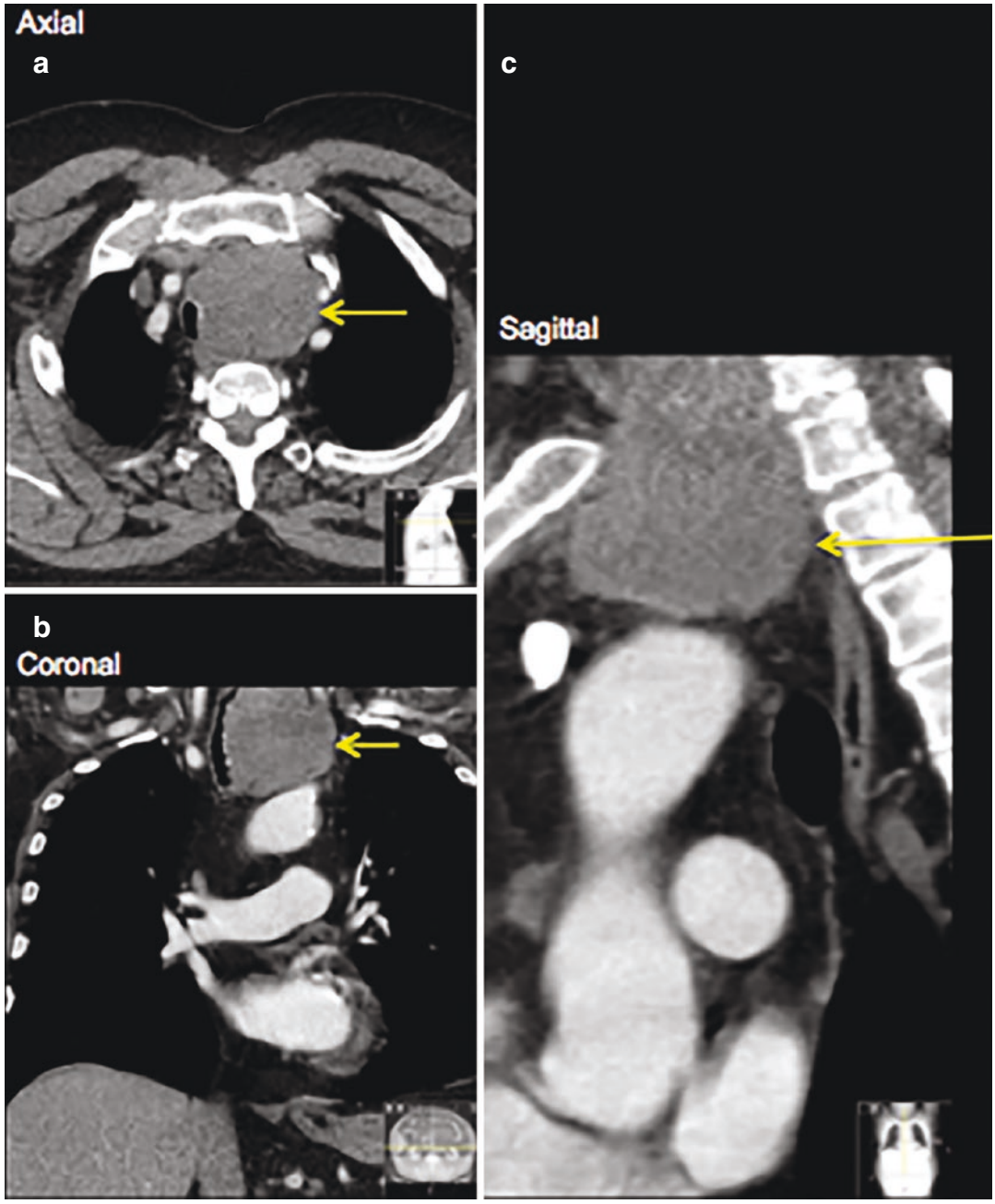
Case 7



A 68 year-old male patient presented with acute right submandibular gland sialadenitis on a long-standing background of reflux symptoms. Imaging and biopsy confirmed poorly differentiated floor of mouth SCC (pT1 pN2c) obstructing submandibular duct and requiring radical local resection, bilateral neck dissections and post-operative radical chemoradiotherapy. The patient developed swallowing difficulties during treatment, likely related to radiation mucositis, and required gastrostomy feeding. This was followed by rapid progression to complete dysphagia secondary to a post-radiation hypopharyngeal fibrotic stricture, confirmed on: (**a**) contrast-enhanced CT (coronal image) with circumferential mucosal thickening in the hypopharynx and larynx (yellow arrow); and (**b**) video fluoroscopy swallow (VFS), on which a stricture (yellow star) corresponded with the luminal narrowing on CT. Combined anterograde and retrograde endoscopic surgery (CARES, endoscopic surgery via the mouth and gastrostomy) was performed with CO_2 LASER for scar division, endoscopic balloon dilatation and NGT insertion. Three weeks later, a rigid pharyngoscopy (under GA) confirmed a patent pharyngo-oesophageal lumen, allowing the patient to eat and drink freely. This is demonstrated on the endoscopic images during rigid pharyngoscopy: (**c**) before; and (**d**) 3 weeks after CO_2 LASER division and balloon dilatation of scar, the patent neopharyngo-oesophageal lumen on the latter permitting oral swallow resumption and gastrostomy tube removal. Five years post-treatment, he is cancer free, swallowing with luminal patency, albeit with ongoing swallow issues in part related to pre-existing underlying LPR

Key Learning Point: A multidisciplinary team approach through an Integrated Care of Swallow (ICOS) MDT with prompt multi-modal imaging access supports optimised swallow functional outcomes for patients. Short and long-term factors may contribute to multi-factorial aetiology in dysphagia, including the sequelae and complications of chemoradiotherapy and LASER/robot treatments in management of primary mucosal malignancies of the H & N.

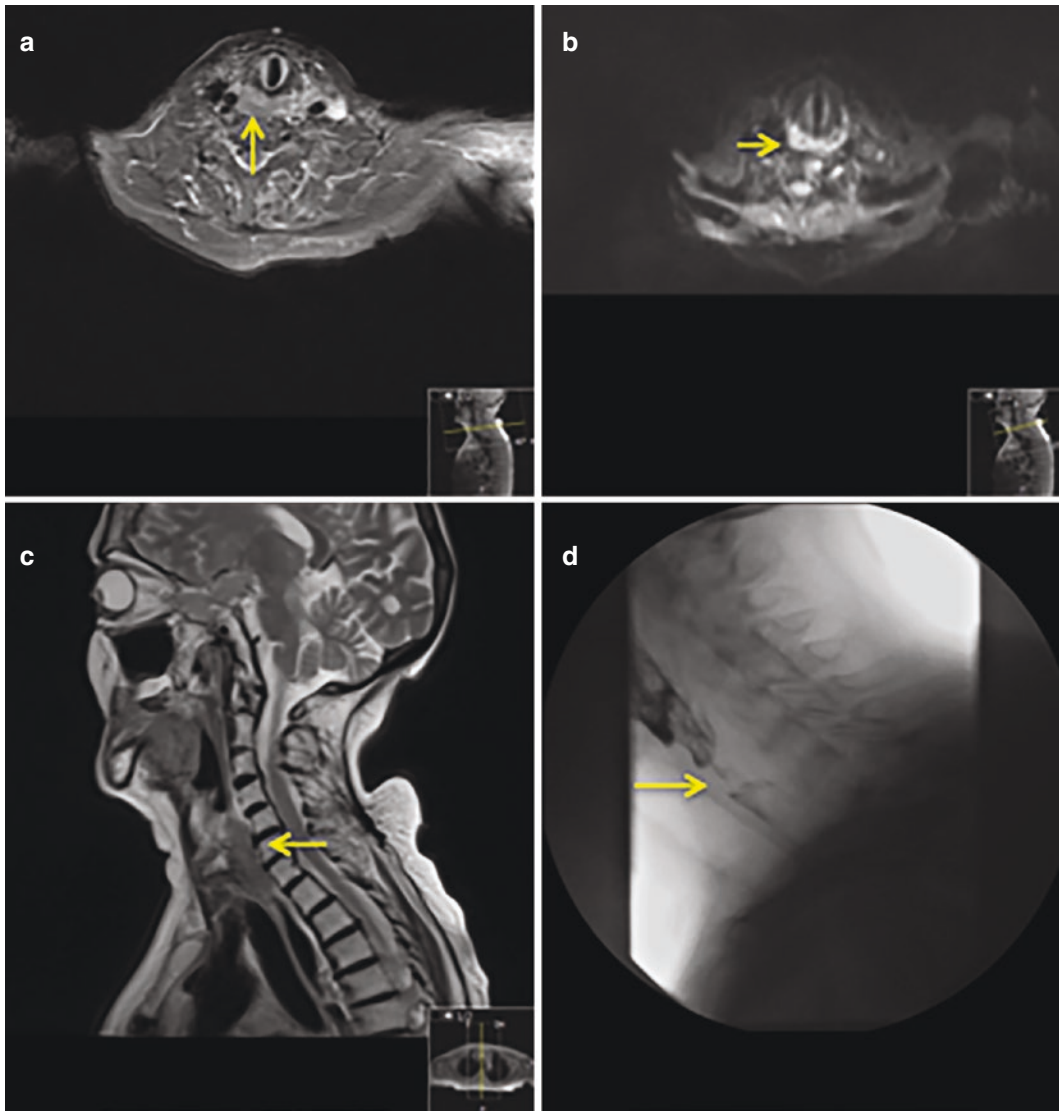
Case 8



A 65-year-old male presented acutely with a central low neck mass, stridor and dysphagia. Axial (**a**), coronal (**b**) and sagittal (**c**) contrast-enhanced CT images at the thoracic inlet showed an enlarged thyroid multinodular goitre (yellow arrow) with a retrosternal component causing right-sided deviation and extrinsic compression of the trachea, plus accompanying oesophagus displacement. The patient underwent total thyroidectomy through a cervical incision with a midline sternal split. Histology confirmed de-differentiated anaplastic thyroid cancer, likely transformed from a focus of well-differentiated thyroid cancer within the goitre

Key Learning Point: CT of the neck and chest in the acute setting, for both dysphagia and stridor, can readily assess and refine the differential for a wide variety of aetiologies. Intrinsic and extrinsic luminal obstruction can be delineated, and altered vital relationships between adjacent organ systems can be appreciated. Appropriate surgical planning and informed consent is facilitated (sternotomy increases perioperative risks for morbidity, warranting a longer post-op HDU and overall hospital length of stay).

Case 9

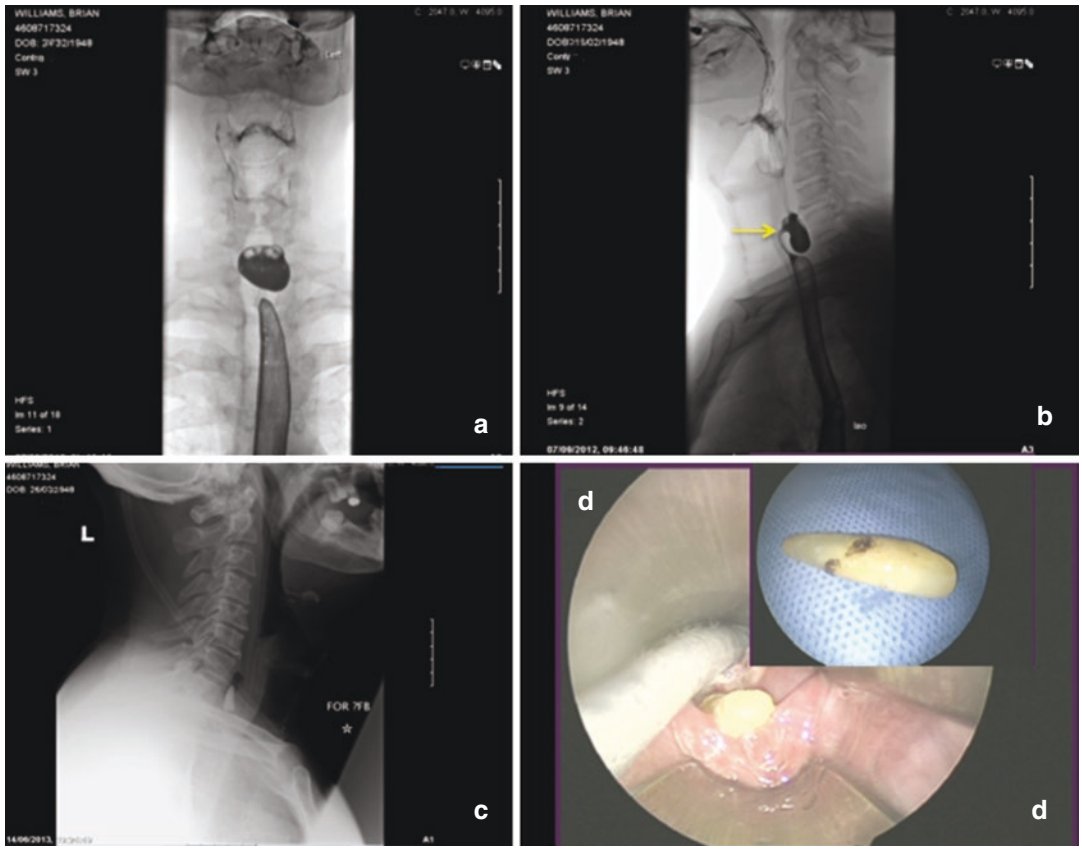


An 83-year-old female was admitted semi-electively at a spoke site, reporting a 4-month history of progressive dysphagia to liquids and solids, weight loss and difficulty throat clearing. Barium swallow (not shown) confirmed an upper oesophageal stricture. OGD was attempted but abandoned by the local gastroenterologist prior to inter-hospital transfer to a tertiary ENT (H & N) unit. Flexible nasendoscopy confirmed salivary secretions pooling in the hypopharynx, but no obvious masses or asymmetry and normal vocal cord motility. Head and neck MRI scans and CT chest were performed prior to rigid pharyngoscopy and biopsy under GA. (**a**) Axial T2W STIR MRI; (**b**) axial b = 800 DW-MRI; and (**c**) Sagittal T2W MRI images revealed a post-cricoid hypopharyngeal mass with intermediate T2W signal and restricted diffusion extending into the cervical oesophagus, larynx and thyroid gland

(yellow arrow). Pre-biopsy barium swallow (**d**) demonstrated circumferential shouldered stricture in the hypopharynx and cervical oesophagus (yellow arrow). Although the imaging features reflected probable hypopharyngeal carcinoma, histology from rigid pharyngoscopy demonstrated inflammatory changes only. Following H & N oncology MDT discussion, USS-guided percutaneous core biopsy was arranged, confirming hypopharyngeal SCC (T4 stage). She required gastrostomy tube insertion for feeding and subsequent palliation through best supportive care

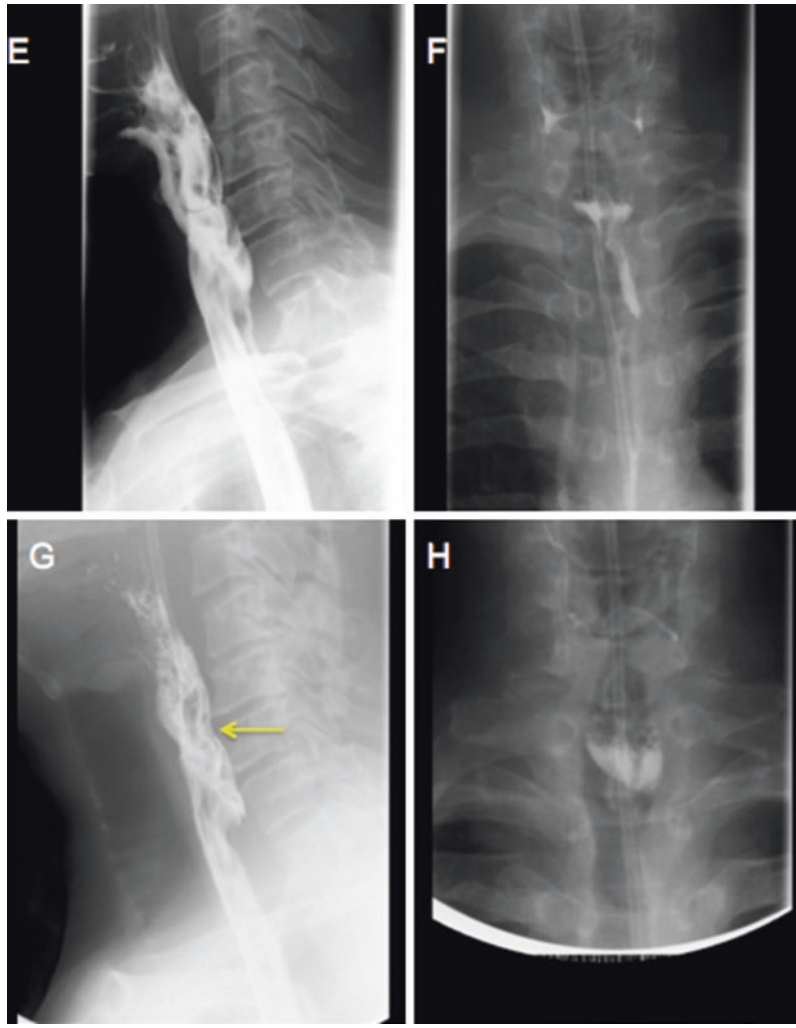
Key Learning Point: Thyroid and hypopharyngeal malignancy can both result in dysphagia. Histological distinction is possible with endoscopic biopsy or USS-guided sampling (fine needle aspiration and cytology (FNAC) or core biopsy). USS-guided techniques avoid a GA, where radiologist support permits. Such cases require clear communication and integrated teamwork between sub-site cancer MDTs to ensure an optimal approach to disease management. Prompt support by an experienced interventional H and N radiologist and subsequent hospital/community palliative care services ensured diagnosis and best-interests outcome for this patient.

Case 10



A 65-year-old male presented to ENT with year long history of perceived swallowing difficulties with solids "sticking" in mid-neck. Barium swallow (**a**) AP; and (**b**) lateral projections confirmed contrast pooling in a wide-necked Zenker's diverticulum, greater than 1 vertebral body height (yellow arrow). Transoral division and stapling of the cricopharyngeus was planned electively however, mucosal ulceration at rigid pharyngoscopy under GA raised suspicion for a pouch-associated SCC. The planned procedure was abandoned with biopsy alone per-

formed, demonstrating inflammation only. However, following extubation, a loose tooth was noted missing. (**c**) A lateral soft tissue radiograph confirmed it to be lodged in the pouch, requiring further GA for its retrieval as shown in (**d**)—images from direct rigid pharyngoscopy and tooth retrieval. Postop suspicioun for pharyngeal tear plus perforation necessitated a gastrografin contrast swallow which reported an equivocal mucosal defect posteriorly and abnormal submucosal tracking of contrast. The patient required nasogastric tube (NGT) feeding for a week with a prolonged hospital stay. Repeat contrast study 1 week thereafter showed a residual pouch but no leak. Through onward referral to a H & N sub-specialist, the pouch was then addressed by direct rigid pharyngoscopy under further GA, with endoscopic CO_2 LASER division of the cricopharyngeal bar and stapling

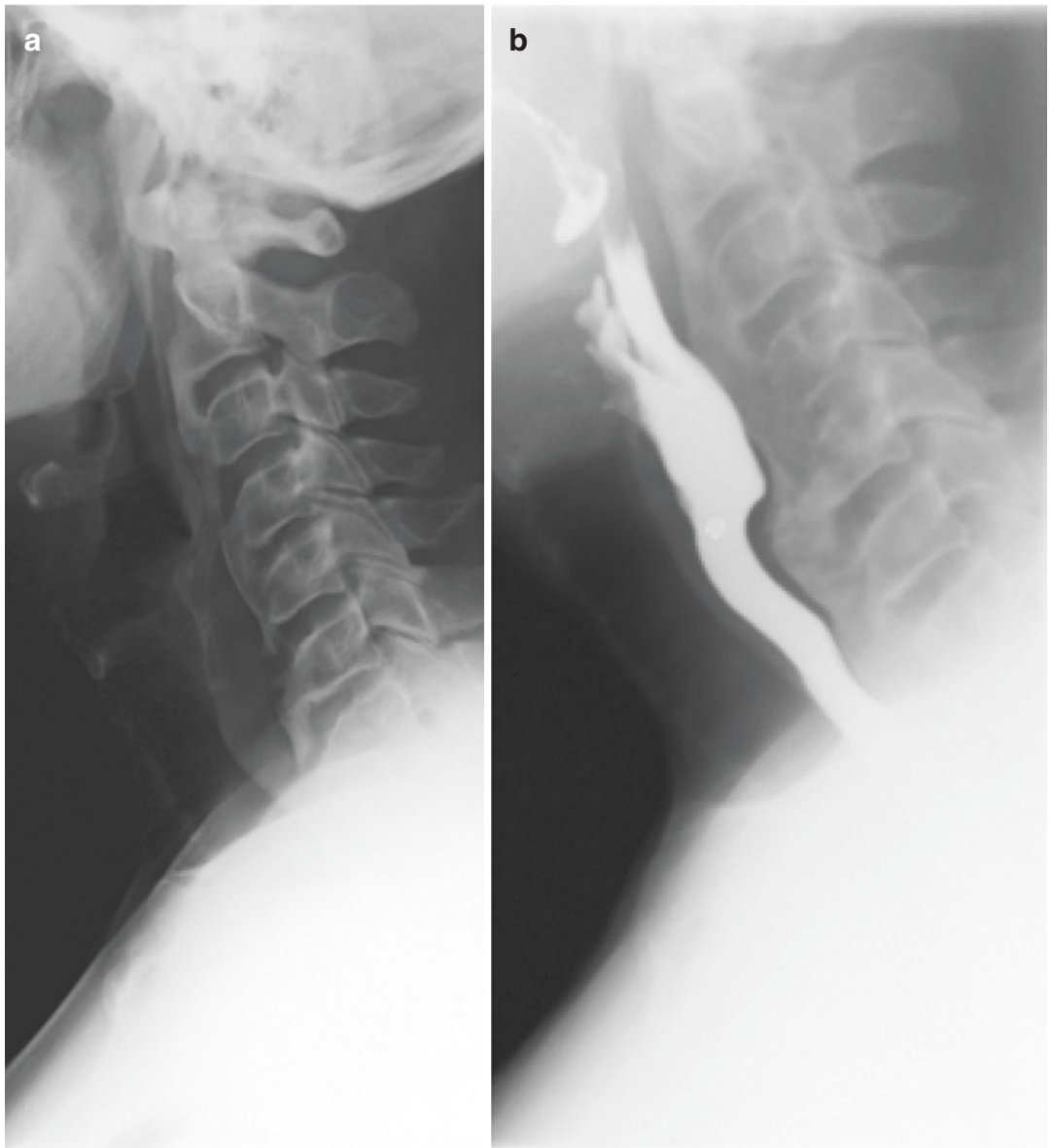


Following surgery, Gastrografin swallow images (lateral view **E** and **G**, AP view **F** and **H**) showed left posterolateral hypopharyngeal mucosal irregularity representing redundant mucosal flap, but no leak, as expected following successful endoscopic cricopharyngeus division for Zenker's diverticulum

Key Learning Point: Zenker's diverticulum is a common cause for high dysphagia and can be addressed using minimally invasive endoscopic approaches. Neck anatomy, cervical spine and tempero-mandibular joint arthritis and fixation, dental and respiratory status, will often all have a bearing on the ease and success of trans-oral endoscopic surgery. Dental trauma is more likely

when access is limited by tooth decay, crowns, caps, dental implants, retrognathia and trismus. Loose teeth, dentures, caps, crowns and implants should be identified, removed or accounted for at the end of all procedures. There is a recognised association between long-standing pharyngeal pouch formation, laryngopharyngeal refluxate and malignant transformation of mucosa.

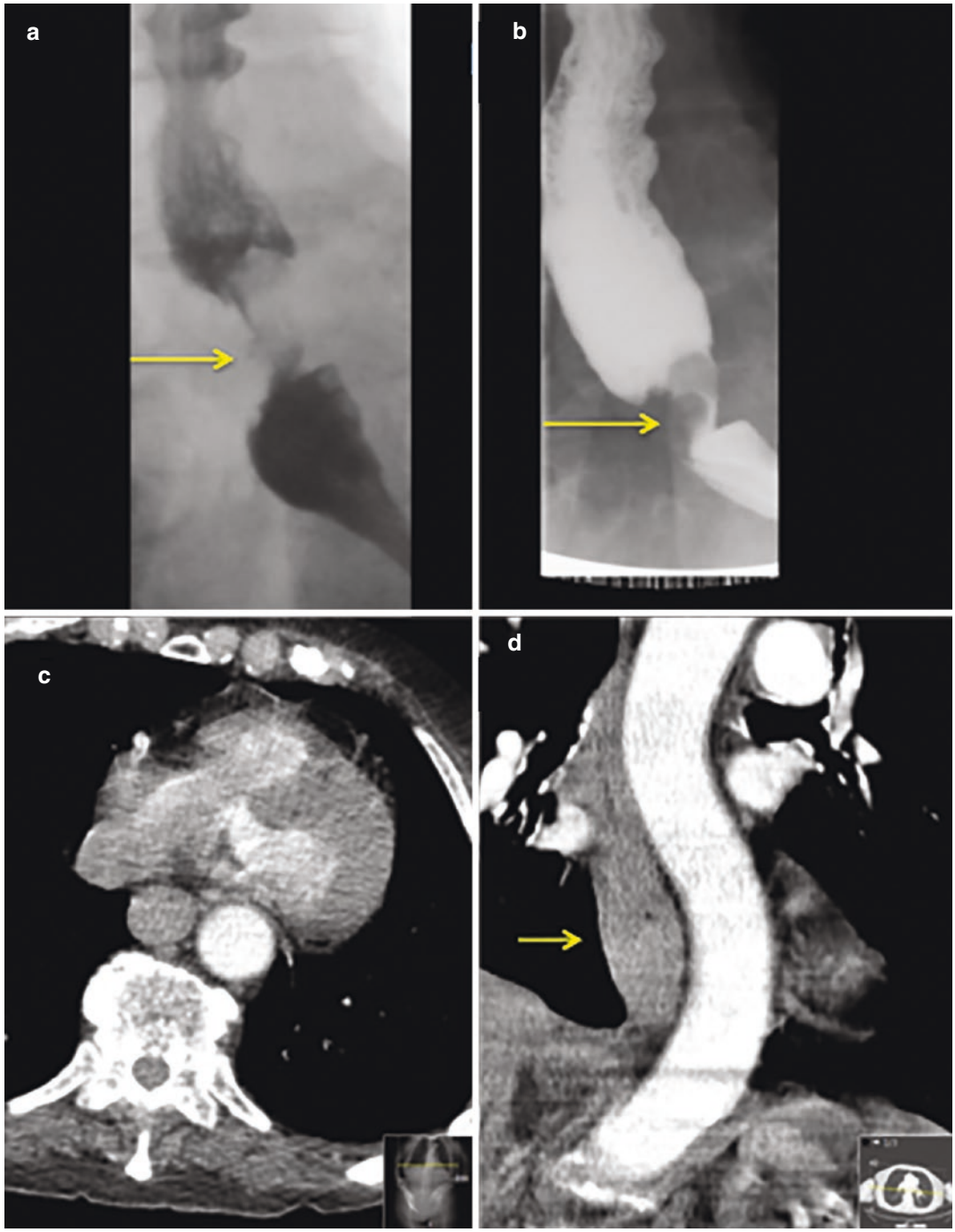
Case 11



Reporting dry solids sticking at the back of the tongue, a 59-year-old male presented electively with progressive swallowing difficulties over a 2 year period. He reported frequent throat clearing, occasional regurgitation and attempts at dietary manipulation to avoid dry bread and biscuits, He denied weight loss, retrosternal burning or dysphonia and reported no coughing, choking episodes or recurrent chest infections. As a victim in a road traffic accident 11 years previously, he sustained a head injury and described a chronic progressive limitation in neck movement. He described neck pain radiating occipitally onto the parietal scalp and into both arms. Clinical examination and flexible nasendoscopy revealed a stiff neck, a prominent gag reflex and inter-arytenoid pachydermia in keeping with advanced laryngopharyngeal reflux. Previously, gastroenterologist-performed OGD for dysphagia confirmed oesophagitis subjectively without biopsy. (**a**) Lateral control radiograph demonstrated florid anterior vertebral osteophytes indenting the posterior pharyngeal wall, confirmed on CT neck (not shown). (**b**) Barium swallow lateral view demonstrated indentation of the cervical oesophagus by the osteophytes, most pronounced at the C5/C6 but without luminal narrowing, as well as gastro-oesophageal reflux, mild oesophageal dysmotility, and an occult hiatus hernia. Following this, SLT-led VFS confirmed reduced hyolaryngeal excursion during the pharyngeal stage of swallow, with mechanical blocking of osteophytes thought to impair epiglottic movement and bolus transit. In the context of multiple synchronous interrelated pathologies, this case was discussed at our Integrated Care of Swallow (ICOS) MDT meeting. High-resolution manometry, repeat texture-variation barium swallows (a larger bread bolus), and a repeat OGD were arranged with oesophageal biopsies to exclude medically treatable eosinophilic oesophagitis. Neurosurgical and rheumatology input raised the possibility of DISH or ankylosing spondylitis rather than degenerative disease related to trauma. Following further MDT diagnostic work-up (neurophysiological investigations on cervical spinal nerve roots), surgery was performed to reduce the impinging burden of these osteophytic bars via an anterolateral cervical approach. This resulted in significant and life-changing symptomatic improvement so that further surgery for the hiatus hernia was deemed unnecessary

Key Learning Point: Often dysphagia will result from interplay of multiple co-existent pathologies. Cohesive team discussion avoids pitfalls and complications from inappropriate management, while comprehensive evaluation requires a combination of imaging modalities, specialist GI/neurophysiological tests, as well as endoscopic assessments. These components may not all be available in the same department or hospital, so regionally structured integrated care of swallow care pathways, and management strategies should permit more optimised and clinically effective team working for improved patient-reported outcomes.

Case 12

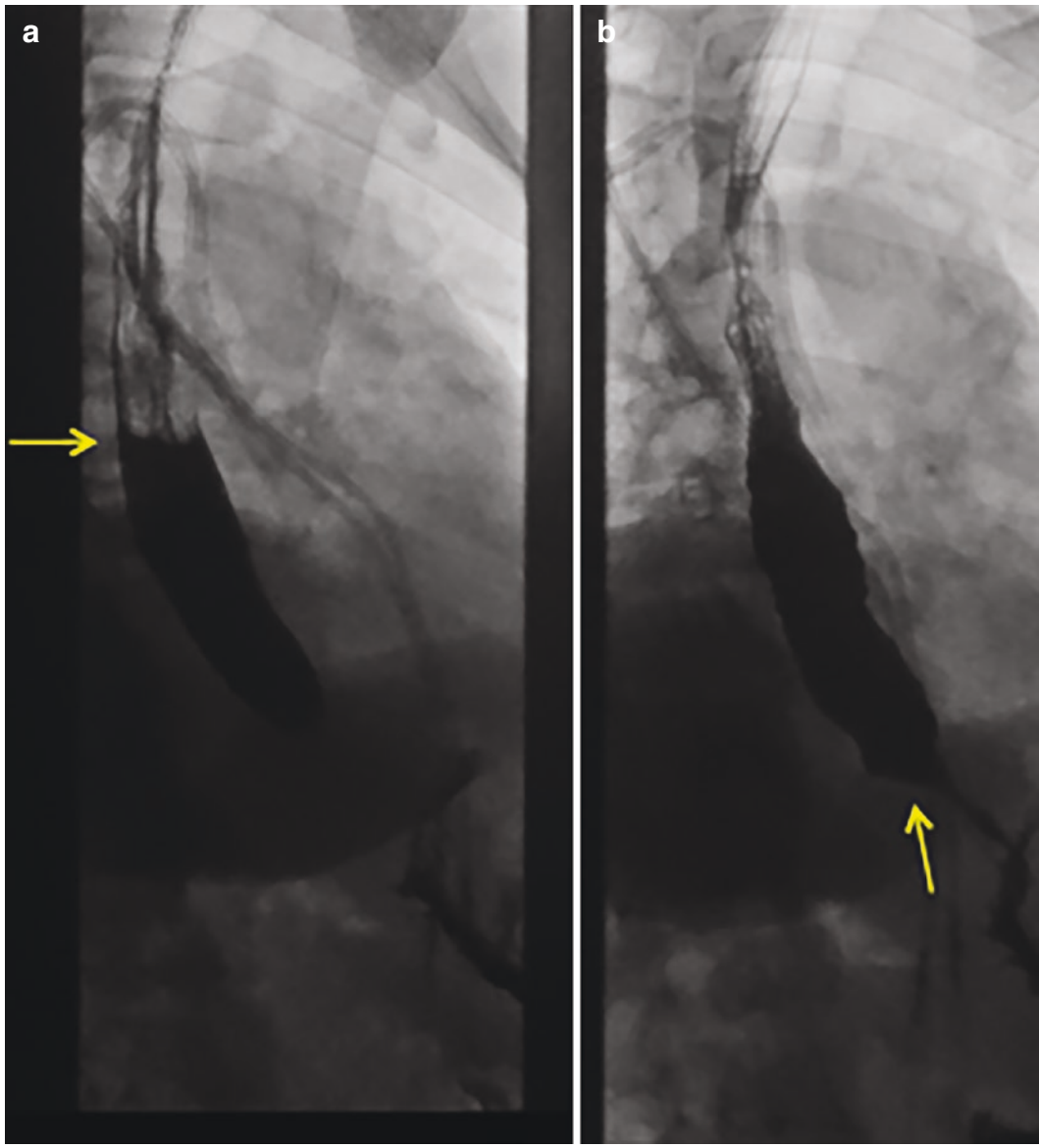


A 92-year-old female presented with progressive weight loss, long-standing swallowing difficulties, food sticking retrosternal (low dysphagia) and occasional associated vomiting. Barium swallow oblique projections (**a**, **b**) demonstrated a 2 cm lower oesophageal shouldered circumferential stricture with "apple-core" appearances, highly suspicious for carcinoma (yellow arrow). This was confirmed at OGD plus biopsy. Contrast-enhanced CT

chest (axial **c** and coronal **d**) images confirmed circumferential lower oesopageal thickening without nodal disease or metastasis, in keeping with T2N0M0 adenocarcinoma that warranted initial lumen stenting to permit continued oral feeding

Key Learning Point: Oesophageal malignancy, often arising from chronic mucosal inflammatory changes (e.g. Barrett's oesophagus), may be evaluated through both radiological and endoscopic luminal tests. Early-stage or pre-cancerous disease (dysplasia/T1 carcinoma) can be missed on CT images and contrast swallow studies, unlike more advanced exophytic disease. Endoluminal ultrasound stages local disease most accurately. OGD with multiple cupped biopsies for the histological report is presently the gold standard for excluding oesophageal cancer.

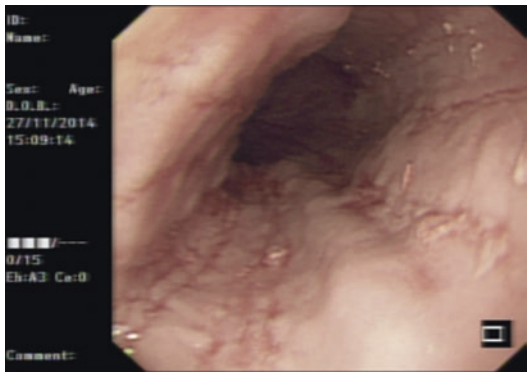
Case 13



A 48-year-old male presented electively to gastroenterology with low dysphagia for both solids and liquids, worsening over 6 months and improved by eating slowly. Contrast swallow oblique images (**a** and **b**) demonstrated incomplete relaxation of the lower oesophageal sphincter (LOS) with "bird beak sign" and delayed transit, in keeping with achalasia

Key Learning Point: Physiological and structural anatomical abnormalities of the oesophagus, conditions such as smooth muscle motility disorders, reflux disease, incomplete relaxation of the lower oesophageal sphincter, oesophageal dilatation and hiatus hernia can all be readily demonstrated on barium study. Provocation tests with solid boluses or textural variations can provide additional information. Endoscopic evaluation augments information gained from oesophageal manometry motility studies.

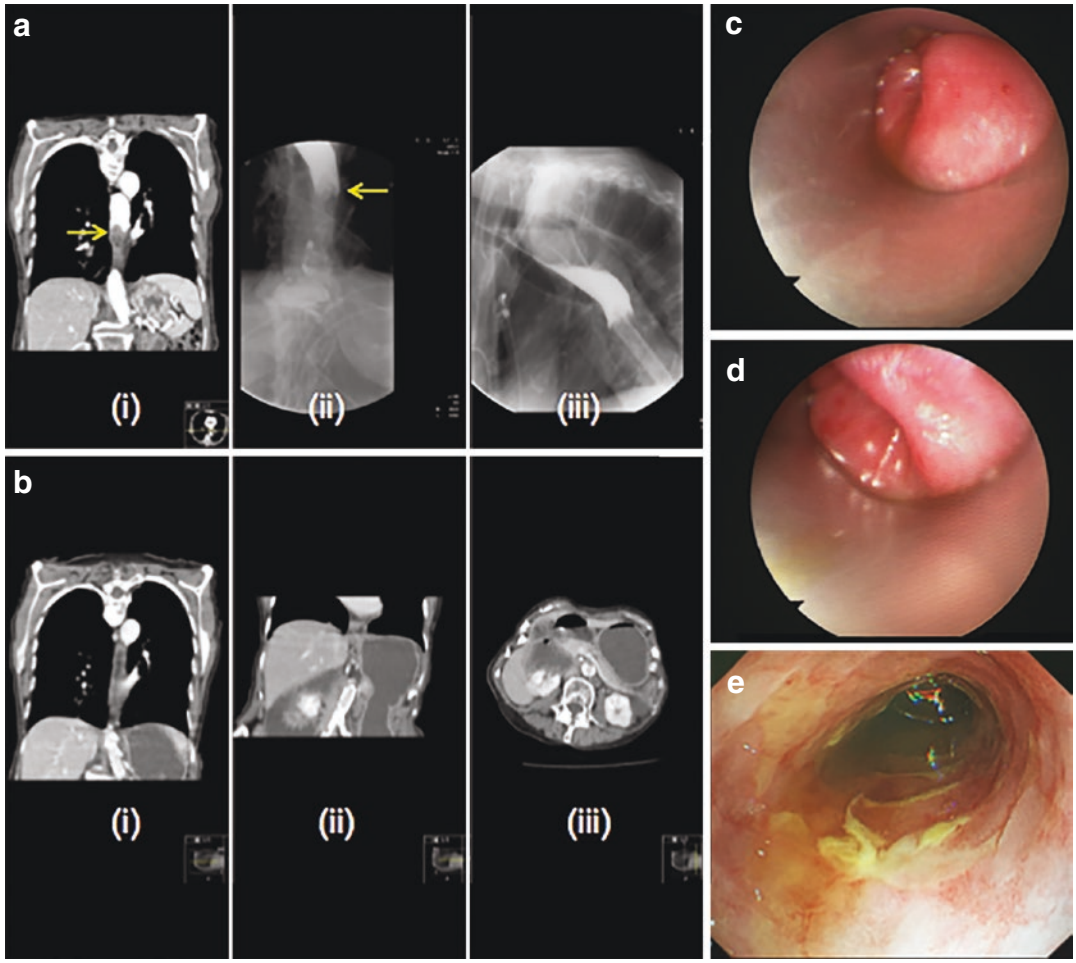
Case 14



A 32-year-old Caucasian male with pre-existing asthma/seasonal rhinitis presents to gastroenterology with chronic intermittent dysphagia to solids over the years. OGD showed "tram-lining" as seen in eosinophilic oesophagitis. Biopsies confirmed this histological diagnosis

Key Learning Point: Eosinophilic oesophagitis is pathologically characterised by an eosinophilic infiltrate on biopsy. Endoscopic signs suggest the diagnosis and management often involve a wider MDT approach, including immunologists, dietitians and respiratory medicine. IgE levels and RAST allergen testing may add weight to the underlying diagnosis and help guide symptom control. Clinicians offering trans-nasal esophagoscopy (TNO) should be familiar with common endoscopic imaging patterns and important conditions affecting the whole combined upper aerodigestive tract and oesophagus, as well diseases that may relate to the whole combined upper and lower respiratory tract, immune system and multi-system connective tissue inflammatory disorders. TNO services should ideally be developed and delivered collaboratively between H and N, gastroenterology and upper GI surgical teams through joint training standards for core knowledge and practical skill competencies.

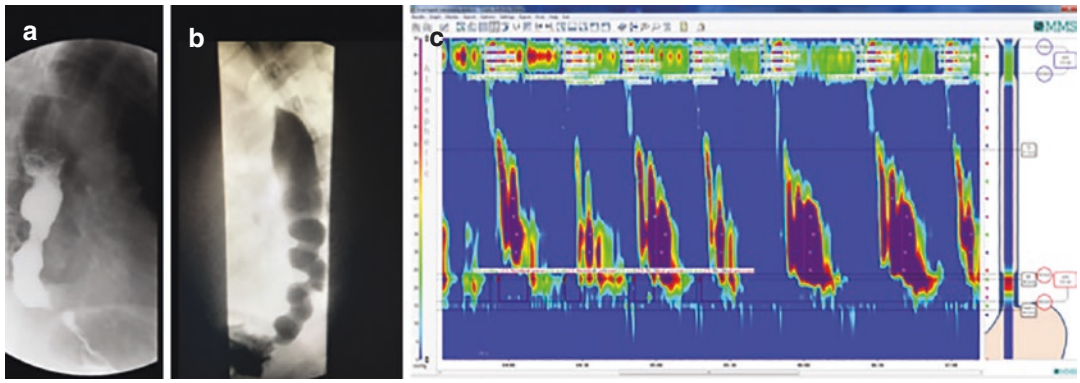
Case 15



An 83-year-old female was admitted via the emergency department to ENT care with acute dysphagia and an impacted chicken food bolus. She required a direct rigid pharyngo-oesophagoscopy with an uneventful bolus removal, but the dysphagia persisted following recovery from general anaesthesia. Urgent imaging, including water-soluble contrast swallow and contrast-enhanced CT of the neck, chest and abdomen was performed. (**a**-**i**) CT chest (coronal) and (**ii, iii**) contrast swallow demonstrated an intraluminal filling defect of mixed soft tissue density (arrowed), with gas distally and dilated proximal upper to the mid oesophagus. Ingested contrast material above the filling defect was indicative of incomplete foreign body removal. Distally, (**b**) CT images through chest and abdomen [(**i, ii**) coronal and (**iii**) axial] showed dilated oesophagus, stomach and duodenum, suggesting proximal bowel obstruction. The patient required repeat anaesthetic and rigid pharyngo-oesophagoscopy. A residual food bolus was removed from the distal oesophagus, and distal inspection revealed a complicating gastric volvulus, from an undiagnosed sliding hiatus hernia. (**c**, **d**) This was demonstrated on the endoscopic images taken through a rigid 0^0 Hopkins rod endoscope. An on-table flexible OGD was performed by local gastroenterology colleagues, allowing oesophageal air insufflation and self-reduction of the volvulus, signalled by gastric reflux of retained material into the oesophagus (**e**). Endoscopic examination of the stomach and duodenum was unremarkable. The patient made an uneventful recovery, eating and drinking normally without further intervention

Key Learning Point: Oesophageal food bolus obstructions and foreign bodies may be managed by both ENT and GI specialist teams. Rigid endoscopic instrumentation may be appropriate for the removal of proximal obstructing masses while a flexible OGD is more appropriate at the mid or distal oesophagus. Pre-emptive radiological imaging can assist in planning for team, technique and equipment requirements. Intrinsic or extrinsic causes may be identified and managed accordingly.

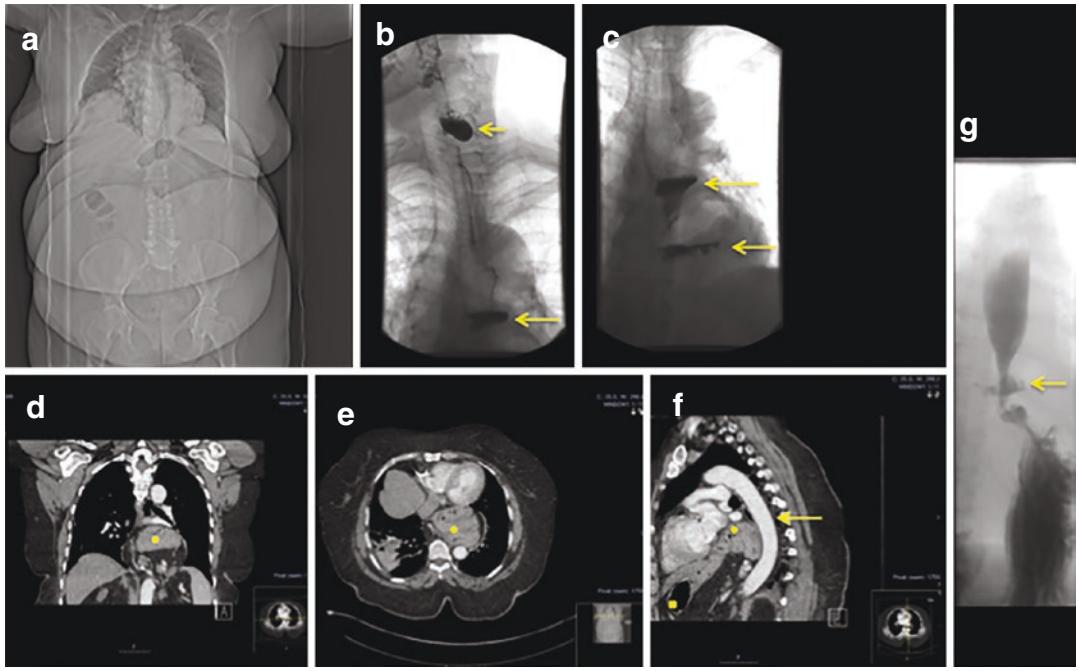
Case 16



A 72-year-old male presented to ENT with 7 year history of swallowing difficulties. Previously, a pharyngeal pouch was diagnosed on barium swallow, which required two attempts at endoscopic stapling before symptom improvement. Regurgitation symptoms and dysphagia to solids improved but did not settle completely. For the last 3 years, he described solids sticking retrosternal with retching and occasional self-induced vomiting, without clear aspiration events or resultant pneumonia. Liquids and pureed foods caused no problem. Following ICOS MDT discussion he was referred to gastroenterology, requiring repeat OGD, barium swallow and impedance manometry studies. (**a**) Contrast swallow confirmed diffuse oesophageal spasm with a "corkscrew" morphology, in association with a recurrent small pharyngeal pouch located higher. (**c**) Oesophageal manometry (a pressure plot where purple colour reflects elevated intraluminal pressures) confirmed characteristic features of diffuse oesophageal spasm, involving rapid premature contractions associated with adequate relaxation of the lower oesophageal sphincter (effectively excluding achalasia). A jackhammer oesophagus is diagnosed when the Distal Contractile Integral reaches >8000 mmHg-cm/s in more than 20% of swallows (Chicago Classification of Motility Disorders). Distal oesophageal spasm can be treated with nitrates (short or long acting), calcium-channel blockers, anticholinergics, 5-phosphodiesterase inhibitors or visceral analgesics such as tricyclic agents or SSRI's. Endoscopic therapy includes botulinum toxin injections or dilatation myotomies (e.g. per-oral endoscopic myotomy, POEM). Following initial good symptom response to domperidone orally, this patient had a POEM procedure performed with sustained success

Key Learning Point: Complex and refractory swallowing difficulties require multidisciplinary team discussions and a progressively invasive strategy for escalating investigations, maintaining considerations for all test modalities, technology availability, MDT expertise, team and patient factors, as well as evidence-base for diagnostics.

Case 17



An obese 74-year-old female presented with acute on chronic progressive dysphagia associated with shortness of breath, coughing and aspiration. A chest radiograph showed right-sided consolidation and antibiotics were commenced. A pharyngeal pouch was diagnosed 3 years previously and managed conservatively. The speech and language therapy team assessed swallow safety and restricted the patient to small sips pending onward investigations. Preceding admission, her diet was restricted to soft and pureed food before liquids proved problematic. Co-morbidities included late-onset diabetes, ischaemic heart disease, hypertension, hypercholestrolaemia, asthma and hypothyroidism. (**a**) CT scanogram of the CT chest/abdomen confirmed obesity. Unable to tolerate an OGD examination, (**b**, **c**) gastrografin contrast swallow was performed, showing a small pharyngeal pouch (upper arrow), as well as a large hiatus hernia and obstructed contrast flow into the distal stomach (arrows show fluid levels within the obstructed oesophagus and the hiatus hernia). As nasogastric tube placement beyond the hiatus hernia was impossible, total parenteral nutrition was commenced, pending definitive management with gastrostomy and jejunostomy. Combined care was arranged between ENT and upper GI surgical teams. Multi-planar contrast-enhanced CT neck, chest and abdomen (coronal **d**, axial **e,** sagittal **f**) demonstrated a large hiatus hernia with hiatal sac (stars) extending cranially between the heart and descending thoracic aorta to the level of T5/6 (arrow). This also confirmed luminal air in the subdiaphragmatic distal stomach (**f**; cross), as well as right lower lobe consolidation (**e**). Following medical optimisation, a trans-oral pouch stapling and CO_2 LASER division of the cricopharyngeal muscle bar was followed by laparotomy for open repair of the hiatus hernia, involving gastric sleeve procedure, cruroplasty and gastropexy. She required extensive post-operative ICU support. Feeding was continued through a gastrostomy, with slow improvement. However, at day 21 post-surgery, (**g**) fluoroscopic swallow to assess oropharyngeal competency and mucosal integrity, revealed a distal oesophageal leak (yellow arrow). Despite prompt CT-guided drainage of an associated small abscess, the patient deteriorated rapidly, succumbing to fatal multi-organ failure

Key Learning Point: Complex swallow problems require close multidisciplinary team working and communication. The clinical environment, minimally invasive surgical technology, specialist medical and surgical expertise, surgical intensive care support with early and continued allied healthcare involvement (SLT/nutritionist) all influence clinical outcomes. Patient age, nutritional status and obesity increase morbidity and mortality risk.

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