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In this article...

- Anatomy and physiology of the mouth and oesophagus
- Role of saliva in chemical digestion and role of teeth in mechanical digestion
- Common conditions affecting the mouth and oesophagus

Gastrointestinal tract 1: the mouth and oesophagus



Nursing Times
Self-assessment

Key points

The gastrointestinal (GI) tract is a muscular tube running from the mouth to the anus

The GI tract breaks down food, which is then absorbed by the body

Mechanical and chemical digestion starts once food enters the mouth

The mouth receives food, tastes it and prepares it for swallowing

The oesophagus ensures the smooth transit of a food bolus from the mouth to the stomach

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Abstract The gastrointestinal tract (gut) runs from the mouth to the anus. Digestion, a mechanical and chemical process, starts when food enters the mouth, where it is chewed by the teeth, moistened by saliva and broken down by enzymes. Once a food bolus is formed, it goes down the pharynx and triggers the swallowing reflex. It then passes through the oesophagus, where two sphincters prevent its regurgitation into the pharynx and mouth, and regurgitation of acidic gastric juices into the oesophagus. The mouth and oesophagus are commonly affected by conditions that impair digestion, such as oral candidiasis and gastro-oesophageal reflux disease. This article, the first in a six-part series on the gastrointestinal tract, looks at the mouth and oesophagus.

Citation Knight J et al (2019) Gastrointestinal tract 1: the mouth and oesophagus. *Nursing Times*; 115: 6, 53-57.

The gastrointestinal (GI) tract, also called the gut, is a muscular tube approximately 9m (30 feet) in length, running from the mouth to the anus. Its function is to mechanically and chemically break down foods from three major food groups – carbohydrates, proteins and fats – into simple components that can be absorbed by the body. It produces various hormones that play a role in regulating digestion, appetite and satiety (feeling of being satiated) and is home to myriad micro-organisms (mostly bacteria) that are essential to health. These form a large part of the human microbiome – the ecosystem of billions of bacteria, viruses and fungal cells that live on or in the body.

This series of six articles describes the anatomy and physiology of the GI tract and some of its common pathologies; part 1 focuses on the mouth and oesophagus.

The mouth

The mouth is the opening of the GI tract - its anatomy is shown in Fig 1. It receives

food, tastes it and prepares it for swallowing (as well as playing a key role in vocalisation). The average volume of the adult mouth is 72ml in men and 55ml in women (Nascimento et al, 2012).

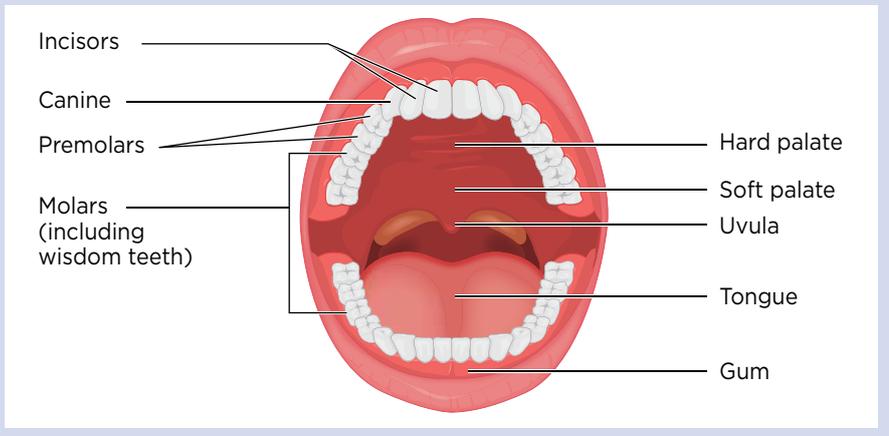
The mouth is lined by mucous membranes and consists of two major regions:

- Vestibule – the space between the inner surface of the cheeks/lips and the teeth;
- Oral cavity proper – the space beyond the teeth, largely occupied by the tongue, where food is chewed and mixed with saliva before being swallowed.

Tongue and sense of taste

The tongue is a muscle that measures approximately 10cm and weighs 60-70g. It is anchored posteriorly to the hyoid bone via small muscles and attached to the floor of the mouth by a thin flap of tissue, the lingual frenulum. Its surface has a rough texture caused by tiny extensions called papillae, which help to grip food as it is moved around the mouth and mixed with saliva. The papillae contain taste buds,

Fig 1. Anatomy of the mouth



which in turn contain gustatory cells that act as taste receptors (Kikut-Ligaj and Trzcielinska-Lorych, 2015).

During mastication (chewing), saliva solubilises food, allowing food-derived molecules to interact with the taste receptors. These receptors are activated and nerve impulses are relayed to the gustatory cortex of the brain, where they are perceived as distinct tastes.

Five major tastes have been identified: salty; sweet; sour; bitter; and umami – a savoury taste associated with glutamate-rich foods, such as fish, cured meat and mushrooms (Kurihara, 2015).

Many textbooks feature a map of the tongue showing where each taste is perceived but these are misleading, as the different taste receptor types are distributed across the tongue (Chamma et al, 2018).

The sense of taste is intimately linked to olfaction (sense of smell) – which is why food cannot be tasted properly if the nose is blocked. As soon as the olfactory apparatus detects the smell of food, the parasympathetic nervous system is activated and stimulates the salivary glands to release extra saliva, preparing the mouth to receive it. Once food enters the mouth, mechanical and chemical digestion starts.

Both olfaction and taste decrease with age, which can make eating less enjoyable and lead to decreased appetite. In particular, the ability to taste salt decreases with age (Mauk, 2010) so older people often add extra salt to food to restore the flavour. This can increase plasma sodium levels, potentially exacerbating problems such as hypertension or kidney disease (Nerbass et al, 2018).

Dentition

Adults normally have 32 teeth, which are evenly distributed between the upper and lower jaws (Fig 1). The teeth comprise:

- Eight incisors – flat, chisel-like teeth that bite into food and break it into small manageable pieces;
- Four canines – sharp, fang-like teeth just outside the incisors that grip and tear food;
- Eight premolars – small teeth between the canines and molars that grind up and cut into food;
- Eight molars – square teeth in the rear of the mouth that grind food to increase its surface area;
- Four wisdom teeth – extra molars that usually erupt after the age of 18 years; they are often removed if problems occur during the eruption process or if they push the other teeth out of alignment because the oral cavity is too small.

Teeth are mainly composed of a bony material (dentine) covered by a layer of white enamel (the hardest material in the human body). Their central portion, the pulp cavity, is composed of living tissue – mostly blood vessels and sensory nerve endings. As teeth are, primarily, cutting and grinding tools, they are susceptible to erosion as a result of

wear and tear as well as exposure to acidic foods (Wang and Lussi, 2012).

Mastication

Mastication is carried out by the teeth, while the tongue moves food towards the premolars and molars. If teeth are missing, the gums can also chew food, although this requires much more effort. Tooth loss is, therefore, associated with decreased food intake, which may lead to nutrient deficiencies (Sahyoun et al, 2003). Chewing mechanically not only makes food easier to swallow but also increases the surface area that is available to the digestive enzymes, thereby enhancing chemical digestion.

The duration of mastication varies according to the food being chewed: soft foods require less time in the mouth than denser foods, such as meats or lightly cooked vegetables. Chewing involves three phases known as the chewing cycle:

- Opening – in which the mandible (lower jaw) is depressed;
- Closing – in which the mandible is elevated;
- Occlusal – when the maxillary (upper) and mandibular (lower) teeth are in contact with each other.

With age, the number of mastication cycles needed to adequately chew a mouthful of food before swallowing it changes; this increases by around three cycles every 10 years (Peyron et al, 2004). This may be due to a reduced grinding surface area (missing teeth) and/or reduced efficiency and strength of the muscles involved in mastication.

Salivary glands

The mouth has three pairs of salivary glands (Fig 2), all innervated by the parasympathetic branch of the autonomic nervous system:

Fig 2. Side view of the mouth

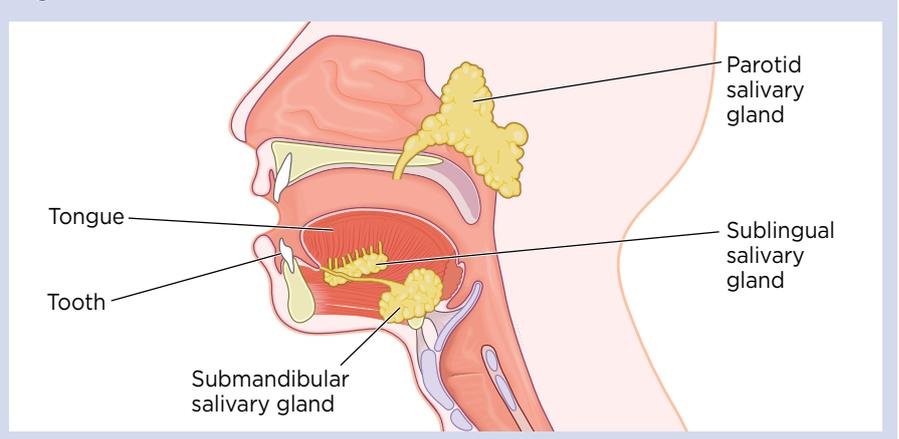
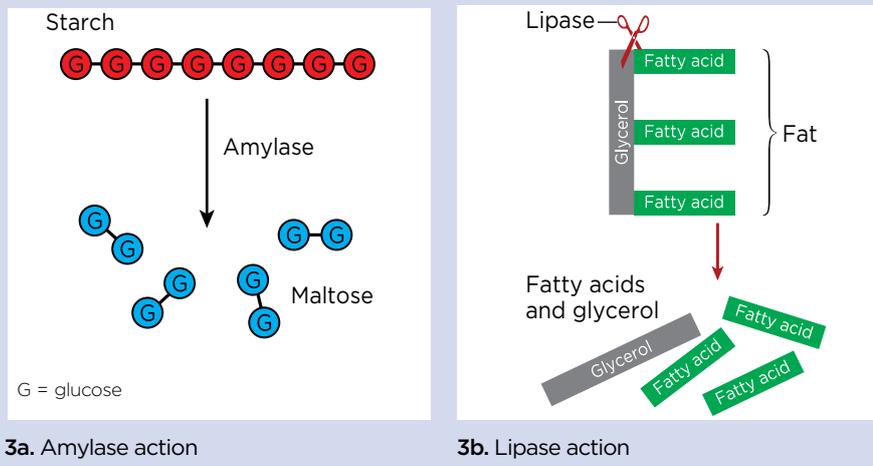


Fig 3. Actions of salivary enzymes



- Sublingual glands – located below the tongue;
- Submandibular glands – located below the mandible;
- Parotid glands – located to the side of the earlobes.

The salivary glands continuously produce small amounts of saliva to keep the mouth moist (basal secretion); in a typical 24-hour period 0.5-1.5L of saliva is secreted. Eating induces a significant increase in saliva production (induced secretion). The submandibular glands do most of the basal secretion and the parotid glands are the major contributors to secretion induced by the presence of food, while the sublingual glands only produce around 5% of both basal and induced saliva secretion (Navazesh and Kumar, 2008). The volume of saliva that is produced can be increased or decreased according to the nature of the food.

The salivary glands produce a glycoprotein called haptocorrin (transcobalamin I), which binds to vitamin B12 to protect it from the acidic secretions of the stomach (Morkbak et al, 2007). The movement and absorption of vitamin B12 in the gut will be explored in parts 2, 4 and 5.

Saliva is also produced by the serous glands of the uvula, a projection from the soft palate that prevents food entering the nasal cavity during swallowing (Fig 2).

Saliva

Saliva is an aqueous solution (Carpenter, 2013) consisting of water (99.5%), mucus, bicarbonate ions, two digestive enzymes – amylase and lipase (or lingual lipase) – and lysozyme. The pH of saliva varies between 6.2 and 7.4, with a neutral pH of 7.0 recognised as optimal for dental health (Baliga et al, 2013). The bicarbonate ions in saliva act as a chemical buffer, neutralising acid

in the mouth to protect the teeth from erosion. Sugar-free chewing gum can protect the teeth as it encourages saliva production, which reduces acidity in the mouth.

The digestive enzymes start the process of chemical digestion. Salivary amylase starts digesting carbohydrates, breaking starch (long linear chains of glucose) into maltose, a disaccharide made of two glucose units (Fig 3a). This is why, after having been chewed, a piece of white bread may taste sweet. Salivary lipase starts digesting fats, breaking them down into fatty acids and glycerol (Fig 3b). It functions optimally at a pH of around 4, so it will not work at its maximal efficiency until reaching the acidic environment of the stomach (see part 2).

Lysozyme, an enzyme found in most body fluids, is part of the non-specific immune defences and acts as a general antimicrobial, attacking and breaking down bacterial cell walls. In the mouth, it starts to kill certain types of bacteria in food, before further sterilisation occurs in the acid secretions of the stomach.

Swallowing

Towards the end of mastication, the tongue and roof of the mouth gather and shape the chewed food into a pellet called a bolus. Moisture and mucus bind and coat the bolus before it is pushed towards the back of the mouth and into the oropharynx (anterior portion of the throat). As the bolus reaches the posterior pharyngeal wall, the swallowing reflex (deglutition) is triggered.

Swallowing involves precisely coordinated muscular contractions. The pharynx walls contract around the bolus, while the epiglottis (a cartilaginous flap-like portion of the larynx) closes over the airway, preventing food from entering the trachea and bronchial tree. The bolus is then funnelled, through the upper oesophageal sphincter, into the oesophagus (Fig 4).

Common mouth conditions

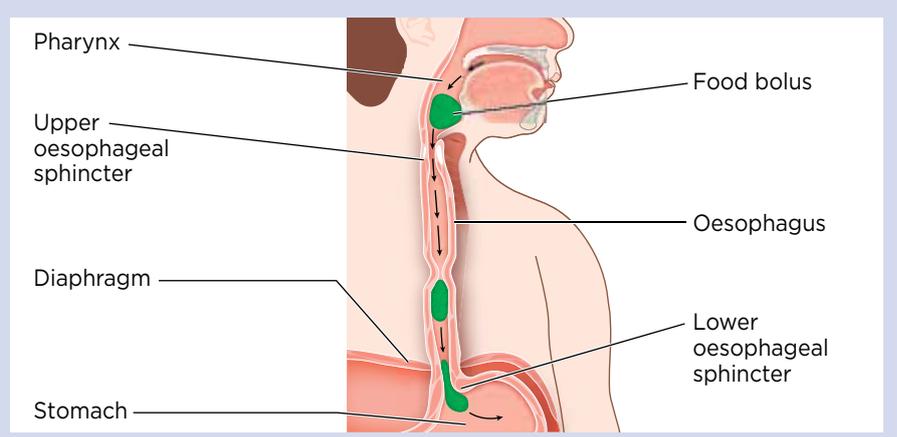
Oral candidiasis

Candida albicans is a yeast usually living harmlessly on the skin, in the GI tract and on mucous membranes such as those of the mouth, nose, sinuses and reproductive tract. However, in certain circumstances it multiplies rapidly, leading to oral candidiasis (thrush), the most common oral infection. A common trigger is the use of broad-spectrum antibiotics, which wipe out the 'friendly' bacteria, such as lactobacillus, that usually outcompete, or slow the growth of, *C. albicans*.

At-risk groups include people with diabetes, in whom excess sugar can encourage rapid proliferation of *C. albicans*, and patients who are immunosuppressed (Singh et al, 2014). Smoking and xerostomia (see below) are further risk factors (Singh et al, 2014).

Oral candidiasis manifests as white spots that can gradually extend and fuse to cover large regions of the oral cavity and

Fig 4. The oesophagus and mechanism of swallowing



tongue. The affected areas often feel very sore and swallowing can be difficult and/or painful. Occasionally, oral candidiasis may extend to the oesophagus and yeast may even enter the bloodstream, causing a risk of sepsis or widespread systemic infection. In most cases, the condition can be resolved using topical antifungal preparations such as nystatin.

Xerostomia and dysphagia

Xerostomia (abnormally dry mouth) is increasingly common with age and often affects people who breathe through the mouth, as this causes moisture to evaporate. Factors such as reduced saliva production, insufficient fluid intake, high alcohol consumption and poorly controlled diabetes can result in, or compound, xerostomia.

Insufficient saliva production is a common side-effect of many medications, including diuretics, certain antidepressants, opioids and many antihypertensives (Bartok, 2011). Xerostomia has been shown to be more likely in patients who take more than four prescription drugs per day (Yellowitz and Schneiderman, 2014). Persistent xerostomia is associated with an increased risk of dry, cracked and split lips, oral candidiasis, mouth ulcers and dental caries; it is therefore detrimental to oral health, and poor oral health is associated with poorer general health.

As moisture in the mouth plays a key role in forming and lubricating food boluses, patients with xerostomia may also have dysphagia (impaired swallowing), which increases the risk of aspiration of food into the airways. Dysphagia is reported to affect 26.7% of people aged ≥76 years, with those who have neurological disease, heart failure or lung disease being particularly at risk (Smithard, 2015).

Patients with xerostomia and/or dysphagia need careful assessment and will often require referral to a speech and language therapist. The nurse's role includes:

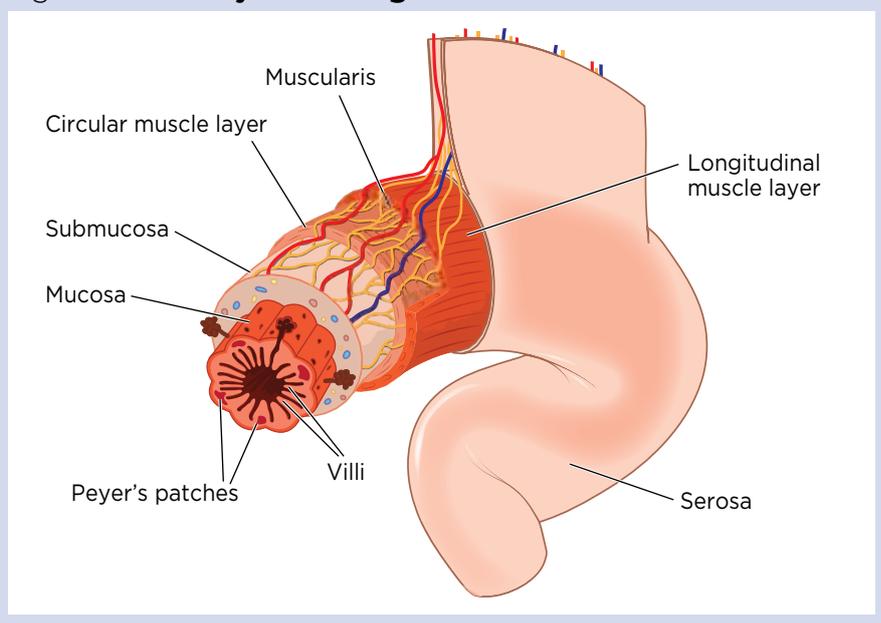
- Ensuring patients are well hydrated;
- Maintaining humidity around the bed (particularly at night);
- Keeping dry and/or crumbly foods to a minimum.

Medications that stimulate saliva production and saliva substitutes may need to be considered (Villa et al, 2014).

The oesophagus

The oesophagus (gullet), around 25cm in length, connects the mouth to the stomach via the pharynx (Fig 4). The oesophagus does not produce digestive enzymes, but it does secrete large amounts of mucus that

Fig 5. The four layers of the gut wall



act as a lubricant, ensuring the smooth transit of the food bolus.

After having been swallowed, the food bolus passes through the upper oesophageal sphincter (UOS), stretching the oesophageal wall and triggering peristalsis (see below). The UOS closes rapidly and tightly to prevent regurgitation of food into the pharynx and mouth. The transit time of food through the oesophagus varies according to factors such as age, health and the nature of the food consumed, but is typically 6-15 seconds (Maurer, 2015).

Once the food bolus reaches the lower portion of the oesophagus, the lower oesophageal sphincter (LOS) dilates, allowing it to pass into the stomach. The LOS (also called the cardiac sphincter due to its proximity to the heart) closes as soon as the bolus enters the superior portion of the stomach to prevent regurgitation of highly acidic gastric juices into the oesophagus. A variety of conditions – for example, hiatus hernia – can lead to poor closure of the LOS and result in acid reflux (see part 2).

The oesophagus is the first portion of the GI tract in which the four layers of the gut wall – the mucosa, submucosa, muscularis and serosa – are recognisable (Fig 5). Each has a distinct structure and role.

Mucosa

The mucosa, the inner lining of the gut, is in direct contact with the food being digested. It is a mucous membrane rich in mucus-producing goblet cells. The mucus they produce lubricates the gut, ensuring

the smooth transit of food. It also coats the mucosa to protect it against digestive enzymes and stomach acid (which may otherwise erode the gut wall). If mucus production is reduced, this protective barrier may be lost, leading to the formation of ulcers (see parts 2 and 3).

The mucosa is folded so it offers a larger surface area. In regions of the gut where nutrients are absorbed, such as the ileum, it has even more folds and extends into finger-like projections called villi, which massively increase the surface area. The mucosa also has small collections of lymphoid tissue (Peyer's patches) that trap pathogens, helping to keep the gut free from infection (Fig 5).

Submucosa

The submucosa, located immediately below the mucosa, is composed of dense, irregular connective tissue that is rich in blood vessels, nerves and lymphatic vessels that extend into the mucosa. It also contains mucus-secreting glands, which release mucus into the gut, adding to the mucus that is secreted by the goblet cells of the mucosa.

Muscularis

The muscularis, the main muscular layer of the gut, is composed of two layers of involuntary smooth muscle:

- An inner layer of circular muscle fibres in concentric rings around the gut;
- An outer layer of longitudinal muscle fibres running along the gut wall.

The muscularis is responsible for the

peristaltic waves that propel food along the GI tract. Peristalsis involves highly coordinated, rhythmic contractions of the circular and longitudinal muscle layers of the gut. The waves are triggered by a dense network of autonomic nerve fibres – the myenteric plexus (or Auerbach's plexus) – which innervates both layers of the muscularis. This network, also known as the enteric nervous system, is so complex, it is often described as a 'second brain' or 'gut brain' (Schneider et al, 2019).

Serosa

The serosa, the outer epithelial layer of the gut, is composed of a thin layer of collagenous connective tissue overlain by a single layer of squamous (thin and flat) epithelial cells. This serous membrane produces a thin, watery secretion (serous fluid) that helps prevent abrasion and friction during movement of the body and gut wall.

Common oesophageal conditions Gastro-oesophageal reflux disease

Most people have experienced the uncomfortable sensation of heartburn that occurs as a result of gastric (acid) reflux. This often happens after eating a large meal that overstretches the stomach and forces the LOS to open, or after eating spicy food that irritates the LOS, causing it to dilate. When gastric reflux becomes chronic, there is a danger that prolonged exposure to stomach acid will cause severe and

painful inflammation, as well as erosion to the mucosal lining of the oesophagus – this is a common condition called gastro-oesophageal reflux disease (GORD).

In addition to causing heartburn, gastric reflux is associated with regurgitation of gastric secretions into the mouth, potentially damaging the teeth, causing bad breath and pain or difficulty when swallowing (NHS Inform, 2019). If untreated or poorly managed, continued gastric reflux can lead to the formation of oesophageal ulcers, which can make swallowing exceedingly painful.

GORD can be effectively managed using antacids or drugs that block the production of acid in the stomach, such as histamine (H₂) antagonists or proton pump inhibitors. Patients with gastric reflux and/or GORD should be encouraged to eat smaller, more-frequent meals and avoid triggers such as spicy foods, fatty foods, chocolate and coffee (NHS, 2017). These simple measures may help them maintain an adequate food intake, while the medications may promote healing.

Barrett's oesophagus

Continual irritation of the oesophageal mucosa can lead to epithelial cells undergoing abnormal structural changes (metaplasia). Abnormal epithelial cells are easily recognisable under a microscope, as they appear tall and column-shaped as opposed to their normal flat (squamous) appearance. Metaplastic changes occur most often at the junction between the oesophagus and stomach, and are usually identified during endoscopy (Graham et al, 2016).

The presence of these abnormal cells is called Barrett's oesophagus and patients with the condition are at higher risk of oesophageal cancer; 1-5% of people with Barrett's oesophagus develop oesophageal cancer (Cancer Research UK, 2016a). Patients require careful monitoring as well as management of gastric reflux symptoms.

Oesophageal cancer

Oesophageal cancer accounts for around 3% of cancers in the UK; it is most frequently diagnosed in people in their 60s and 70s, men being at greater risk than women. Other risk factors are obesity, high alcohol consumption, smoking, GORD and Barrett's oesophagus (NHS, 2016).

Many people do not experience symptoms until the disease is advanced and tumour masses begin to interfere with food transit. Common symptoms include dysphagia, regurgitation, pain, heartburn and weight loss (NHS, 2016). Although

treatments for oesophageal cancer have improved, the outlook for those with advanced disease is poor, with only around 4% surviving for ≥5 years (CRUK, 2016b). **NT**

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