Alimentary Sphincters and their Disorders

Edited by
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Preface

What is a sphincter? It used to be thought that the function of the specialised areas defined as 'sphincters' was to delay the onward passage of the fluids and solids from the organs which 'emptied' through them. It is now realised that this concept was too facile, and that these zones act in a very complex regulatory fashion and that they are able to change their functions to suit the requirements of the whole gastrointestinal tract. Nor is the organisation of each sphincter an exact replica of the rest: some are 'closed' and some are 'open'; some have a well-defined anatomical structure, others are not defined at all; some act as 'brakes' but others can possess an acceleratory characteristic.

With the increasing power of modern pharmaceutical ingredients, many of which (e.g. ganglion-blocking agents and prostaglandins) act directly on the smooth muscle of the alimentary canal, as well as the much increased safety and numbers of major surgical interventions, we considered it appropriate to draw together the current knowledge and ideas concerning the sphincters of the gastrointestinal tract. As these sphincteric regions are perhaps the most widely investigated areas of alimentary motor function, they provide well-defined examples of the correlation between gastrointestinal motor dysfunction and recognised clinical disorders. It is hoped that showing how they perform their functions will stimulate further research as well as increasing the respect that they deserve from all those physicians and surgeons who interfere with them.

The book would not have been possible without the full co-operation of the contributors. Each has brought to his work a high level of expertise, thoughtfulness and clarity of expression. It is especially relevant that most of the contributors are actively involved in the practice of clinical gastroenterology, which has enabled them to provide a relevant correlation between basic scientific data and the clinical disorders of sphincteric

function. We are extremely grateful to them all for their contributions.

On a sad note, we have to report the untimely death of Mr David Reeve, whose surgically orientated chapter on the anatomy of alimentary sphincters provides the introduction to this book.

We are indebted to Ms Linda Bray for helping with the editing and typing of the manuscripts, together with Ms Lynda Randall, Diane Tolfree and Jenny Bignold.

Finally, our publishers have been helpful throughout, and we are grateful to Mr R. M. Powell of Macmillan Publishers for his succinct advice on the practicalities of producing a book such as this one.

London, 1981

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Anatomy of the Sphincters of the Alimentary Canal

D. R. E. Reeve

INTRODUCTION

The word 'sphincter' is derived from the Greek *sphingein* (to bind tight), and means a ring-like muscle which controls the opening of a body orifice or constricts the lumen of a natural body passage.

Sphincters are found in the respiratory, genito-urinary and alimentary tracts, but particularly in the latter. This is only to be expected, considering the complex changes of physical and chemical form which take place in ingested materials during their delayed passage from mouth to anus. It is this delay which is one of the essential functions of the alimentary sphincters. Food is delayed in the stomach while it is mixed with acid and enzymes; this mixture is then delayed in the small intestine during digestion and absorption; and finally the faeces are delayed in the colon and rectum for water and ion exchanges and for storage prior to expulsion when the opportunity arises. Looking overall at sphincters, this is an oversimplification. There are many other functions which may be attributed to sphincters and there are many functional aspects which are, as yet, imperfectly understood. Of the more obvious specialised functions, for example, the larynx presents a primary method of defence against the inhalation of ingested food, the cardiac sphincter prevents the reflux of gastric contents into the oesophagus, and the anal sphincters maintain faecal continence.

An anatomical study of the well-recognised sphincters runs into difficulties if the traditional definition of a sphincter is adhered to—i.e. the demonstration of a ring-like muscle controlling a body opening or natural passage. In some instances (the gastro-oesophageal sphincter, for example) no ring-like muscle can be demonstrated in man, and yet clearly a functional sphincter exists. In such cases the anatomical horizons have to be widened beyond the accepted conventions of the subject in order to relate the physiological aspects of the subject to the architectural structure, which may fail to concur with the expected traditional anatomical arrangement. It is unfortunate that we have burdened ourselves with terminological distinctions such as 'anatomical sphincter' and 'physiological sphincter' when the functional result is the same, rather than to correlate the anatomical facts with the functional mechanisms as they become known. This is especially true of the alimentary tract, which is becoming more and more physiologically complex and where structural dogmatism can add little to the advancement of function understanding.

PHARYNX

There are three well-recognised sphincter mechanisms to be considered in the pharyngeal part of the gastrointestinal tract. First, the palatopharyngeal sphincter, which prevents the bolus from passing upwards into the nasopharynx during swallowing; second, the larynx, which prevents the inhalation of swallowed liquids and solids; and third, the cricopharyngeus, which acts as an upper oesophageal sphincter which relaxes to allow the bolus to pass into the oesophagus.

Palatopharyngeal Sphincter

This is formed by a constant band of muscle which is considered to be part of the palatopharyngeus muscle and is often termed the palatopharyngeal constrictor muscle. It arises from the lateral and anterior aspects of the superior surface of the palatine aponeurosis, and passes backwards lateral to levator veli palatini to unite with the muscle of the opposite side on the anterior surface of the superior constrictor muscle with which it blends. This band produces a ridge on the pharyngeal wall when the soft palate is elevated during swallowing, known as the ridge of Passavant. The soft palate, duly tensed and elevated, meets the protruding fold, forming an effective seal to protect the nasopharynx. As swallowing proceeds, the palate and fold move downwards, carrying the bolus with them. It has been suggested by Ramsay *et al.* (1955), using cinefluorography, that Passavant's ridge is produced, at least in part, by the localised activity of the superior constrictor muscle, because Passavant's ridge, as it descends during swallowing, is often succeeded by a second and lower fold in the posterior pharyngeal wall. This may be true, but that a major role during swallowing is played by the palatopharyngeal constrictor muscle is strongly suggested by the considerable hypertrophy of the muscle that occurs in cases of complete cleft palate.

The Larynx

The primary function of the larynx is to act as a sphincter to protect the respiratory passages during the act of swallowing; phonation should be considered to be a secondary function. The detailed anatomy of the larynx is not pertinent here, but the relevant structures which are held to be responsible for this function may be briefly listed.

The Epiglottis

It has been said by Ramsay *et al.* (1955) that as the larynx rises during swallowing the epiglottis folds backwards over the larynx. This protective function has been affirmed and denied, both before and after this report, and the exact mechanism and purpose of this proposed movement, passive or active, remains a mystery. However, it seems clear that the epiglottis, in any case, functions as a diverter of the bolus away from the midline through the piriform fossae into the hypopharynx. It appears unlikely that it is the major laryngeal sphincter mechanism, because patients who have the epiglottis removed for carcinoma, or those in whom it has been destroyed by disease, have no difficulty in swallowing.

The Sphincter of the Inlet

The free upper edge of the quadrate membrane contains a muscle, the aryepiglottic muscle, which connects the sides of the epiglottis to the opposite arytenoid cartilage. This muscle has been conceived of as being a complete sphincter of the laryngeal inlet which, on contraction, opposes the arytenoids to each other and to the posterior surface of the epiglottis in the region of its cushion. This muscle is not always well developed around the free edge of the quadrate membrane, in which case its function is ascribed to the thyro-epiglottic muscle, which lies outside the quadrate membrane.

The Vestibular and Vocal Folds

It seems unlikely that these folds act as the primary laryngeal sphincters, but rather as secondary mechanisms of defence. However, Ramsay *et al.* (1955) considered that the vestibular fold and sometimes the vocal folds are responsible for the protection, particularly in the case of liquids, of the laryngeal inlet.

In cases where the aryepiglottic and thyro-epiglottic muscles are paralysed (e.g. by damage to the recurrent laryngeal nerves), the inlet of the larynx is not closed during swallowing, and the lax aryepiglottic folds collapse medially and allow fluids to overflow into the larynx. Even so, in these patients inhalation is comparatively rare, and the isthmus must be protected in these cases by the vestibular and vocal folds in the absence of any alternative sphincter mechanism.

Cricopharyngeal Sphincter

Around the upper end of the oesophagus there is a collection of almost circular muscle fibres belonging to the inferior constrictor muscle, which normally keeps the oesophagus closed off from the hypopharynx. This muscle relaxes in advance of the propulsive contractions of the constrictor muscles of the pharynx during the act of swallowing.

The inferior constrictor is the thickest of the constrictor muscles and consists of two parts, named after the origins of the particular muscle fibres—the thyropharyngeus and the cricopharyngeus. The muscle arises from the oblique line of the thyroid cartilage, from an area of the surface of the lamina behind this line and from a tendinous band which passes from the inferior thyroid tubercle to the cricoid cartilage. In addition, a small slip of muscle arises from the inferior cornu of the thyroid cartilage; the whole of this muscular origin constitutes the thyropharyngeus.

Muscle fibres which arise from the cricoid cartilage in the interval between the origin of cricothyroid anteriorly and the articular facet for the inferior cornu of the thyroid cartilage posteriorly constitute the cricopharyngeal part of the inferior constrictor. The fibres of thyropharyngeus pass backwards, medially and upwards as far as the pharyngeal ligament and insert with the muscle of the opposite side into the pharyngeal raphe, which lies in the posteromedian plane of the pharyngeal wall. Some of the fibres of cricopharyngeus insert in a similar fashion into the pharyngeal raphe, but the inferior fibres are circular and continuous with the circular muscle layer of the oesophagus. The ascending fibres of thyropharyngeus surround the middle constrictor muscle where the lumen of the pharynx is widest; descending from this point, the lumen decreases in size and is at its narrowest at the level of the circular fibres of the cricopharyngeus muscle. During the act of swallowing, the middle constrictor muscle and the thyropharyngeal part of the inferior constrictor act as propulsive muscles for the bolus, while cricopharyngeus acts as the sphincteric part of the muscle, which relaxes to allow of the passage of the bolus into the oesophagus.

Pharyngeal Diverticula

These occur in the lower part of the pharynx in most instances, close to the junction of the pharynx and oesophagus. Various causes have been ascribed to the formation of these pouches, the most common being that they are pulsion diverticula which herniate through an area of congenital weakness in the muscle coat of the pharyngeal wall. This appears to be most unlikely, at least as regards a congenital weakness, as most occur in later life and are rare before the age of 20 years.

Pharyngeal diverticula have been noted in cases of oesophageal obstruction, and it is easy to visualise that the increased muscular power produced by the pharynx in an effort to overcome the oesophageal obstruction could cause a mucosal hernia through an area of weakened muscle. In most cases of pharyngeal diverticula, however, there is no obvious oesophageal obstruction. Killian (1908) suggested that a mechanical obstruction could be produced by the cricopharyngeus going into spasm during the act of swallowing, which could eventually result in the formation of a pulsion diverticulum. As yet, there is no conclusive evidence to support or disprove this hypothesis, although it is difficult to imagine what could produce spasm in the cricopharyngeus without causing noticeable dysphagia to the patient, a symptom rarely complained of prior to the formation of the diverticulum. Killian suggested that with increased tone in the cricopharyngeus a raised hypopharyngeal pressure could be produced on swallowing by a failure of this muscle to relax. He considered that the main supportive argument for this concept lay in the nerve supply to the inferior constrictor muscle. The thyropharyngeal part of the inferior constrictor is supplied by the pharyngeal plexus; the motor component arises from the nucleus ambiguus in the medulla, which sends efferent fibres via the cranial part of the XI (accessory) nerve to join the X (vagus) nerve at the base of the skull which distributes a pharyngeal branch to the pharyngeal plexus. The cricopharyngeal part of the inferior constrictor, however, is supplied to the recurrent laryngeal nerve, a branch of the X (vagus) nerve which loops around the ligamentum arteriosum on the left and the subclavian artery on the right side, and by the external laryngeal branch of the vagus. Killian suggested that asynergia between the two nerve components of the inferior constrictor muscle, motor via the pharyngeal branch to thyropharyngeus and inhibitory via the recurrent laryngeal branch to cricopharyngeus, might be a precipitating cause for pharyngeal herniations.

As regards the site of pharyngeal diverticulae, accounts vary as to whether herniation occurs through, above or below cricopharyngeus. Laimer described a triangular area (figure 1.1) situated just below the cricopharyngeus where the posterior oesophageal wall is particularly thin, as the longitudinal fibres of this organ are sweeping laterally, upwards and forwards to reach their attachment to the midline ridge on the cricoid lamina. Consequently, only circular muscle is found in this triangular area and would appear to be a potential site of weakness, although Moynihan (1927) denies this. Killian (1908) went further in his description of

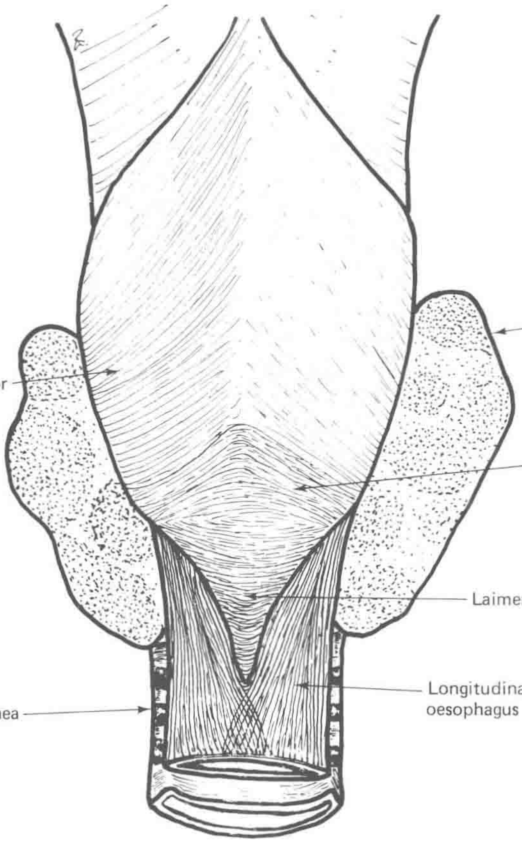

Figure 1.1 Diagram of the posterior wall of the hypopharynx, showing Laimer's triangle.

cricopharyngeus by demarcating two components of this muscle: the ascending constrictor fibres, which he considered to be supplied by the pharyngeal plexus, and the lower purely sphincteric part, which he considered to be the only portion of cricopharyngeus supplied by the recurrent laryngeal nerves. He stated that the effects of muscular asynergia of the two components would be felt maximally at this area of muscular dehiscence (figure 1.2).

Moersch and Judd (1934) thought that the herniating mucous membrane pierced the muscle between the cricopharyngeus and thyropharyngeus. There is, however, very little difference between this spot and that described by Killian, the difference depending purely on which muscular fibres are designated to belong to the cricopharyngeus or the thyropharyngeus. To all practical purposes, these arguments are not important in the clinical situation, as the symptoms, signs and approach to treatment are quite

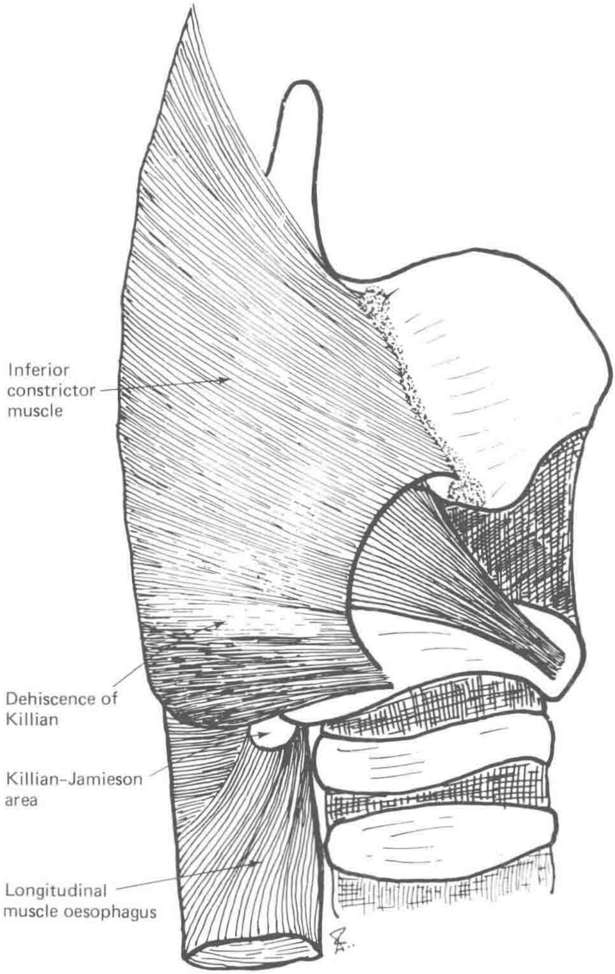

Figure 1.2 Diagram to show the dehiscence of Killian and the Killian–Jamieson area, through which the inferior laryngeal neurovascular bundle enters the larynx.

independent of the exact site of the diverticulum. Although the symptoms of a pharyngeal diverticulum can be distressing for the patient, many diverticula are large when first seen, and at operation are found to lie between the prevertebral and pretracheal fasciae to produce pressure on the surrounding structures of the neck. The fact that they are large makes it difficult for the surgeon to define the exact origin of the hernia; the neck of the sac is often correspondingly large and wide, and the anatomy so distorted that even the correct plane of origin (posterior or lateral), let alone the precise definition of the muscular component, is impossible to discover.