SWALLOWED BONES

by

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This is to certify that this essay,

SWALLOWED BONES

presented to the Faculty of Surgery, University of Cape Town, in partial fulfilment of the requirements for the degree of Master of Surgery (Otolaryngology), is my own unaided work and has not been submitted, in whole or in part, for any other degree.

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PART 1.

INTRODUCTION

SWALLOWED BONES

The purpose of the author's investigation into the problem of swallowed bones, was to enable him to deal correctly with the patient complaining of having swallowed a bone.

The reasons for investigating bones as opposed to other swallowed foreign bodies were :

(a) Bones are by far, the most common type of swallowed foreign body causing patients to seek medical attention.

(b) Bones are frequently not radiologically demonstrable and therefore clinical assessment is of prime importance.

(c) Bones, by virtue of their organic structure, give rise to serious complications sooner than other foreign bodies.

The information required to deal with these patients, numbering approximately 155 cases per year attending

Groote Schuur Hospital, was sought in standard textbooks.

Thomson and Negus (1948), in their standard British work entitled Diseases of The Nose and Throat, devote three pages to oesophageal foreign bodies. They describe the symptoms but do not evaluate the significance of the symptoms.

In Logan Turner's "Diseases of the Nose, Throat and Ear" (1952), one gets the impression that all non-opaque foreign bodies in the oesophagus can be demonstrated on a radiograph by coating them with barium taken by mouth. This disappointing aspect of radiological diagnosis will be dealt with later.

Scott Stevenson (1949) in "Recent Advances in Oto-Laryngology" has included a chapter on bronchoscopy and oesophagoscopy but does not deal with the diagnosis of foreign bodies.

Morrison (1948) in "Diseases of the Ear, Nose and Throat" does not deal with the diagnosis of the presence of a foreign body. He advises endoscopic examination in all

children and in all tracheobroncho-oesophageal cases. He quotes Jackson, "98% of all foreign bodies in the air and food passages can be removed endoscopically in well-trained hands with the risk of 2% mortality." This is not a small risk. It will be referred to later.

Hall (1946), in "Diseases of the Nose, Throat and Ear", mentions foreign bodies in the pharynx but not in the oesophagus.

Scott-Brown (1952), in "Diseases of the Ear, Nose and Throat", makes a useful contribution but does not provide detailed information on the management of cases of swallowed foreign bodies.

Several surgical textbooks were consulted, including Christopher (1946). These in no way attempt to deal with the problem of swallowed foreign bodies.

After failing to obtain a working knowledge of the management of patients who had swallowed bones, all available publications in the English language were consulted.

These articles bear a striking similarity to one another in one important respect. They are all accounts of swallowed foreign bodies and their subsequent removal with or without complications. They leave a regrettable void of information on the indications for direct endoscopy while leaving no doubt in the reader's mind of the immense danger of attempted removal inexpertly performed.

Mosher (1935), Professor of Otolaryngology, Harvard Medical School, at a symposium on foreign bodies, said, " .....the great point about foreign bodies is to remove them without lacerating the oesophagus because given the right bacteria, the posterior mediastinum infects more readily than the peritoneum or the dura. Every oesophageal examination, every passage of a bougie with or without ether, is a potential tragedy."

Clerf in the same year wrote, "..... the untrained endoscopist who does an occasional bronchoscopy or oesophagoscopy has few successes to report; he subjects his patients to unjustifiable hazards. In no field of medicine do end results bear such a definite relationship to training, skill, teamwork and other factors. In foreign body work end-results are positive. Either the foreign body is or is not removed but injury to the

patient may convert an apparent success into a failure."

Tucker (1925), reporting a retropharyngeal abscess as a complication of a penetrating fish bone, described a sign which is useful but applicable only to some cases of cervical oesophageal foreign bodies. Moving the trachea or larynx towards the point of localised tenderness, as indicated by the patient, by pressure from the opposite side of the neck, causes a marked increase in tenderness and pain at this point only while the foreign body is present. There is no change in tenderness if the foreign body has been removed or passed on.

Having consulted textbooks and publications without finding the information sought, a third source of information was pursued with even less success - the records of patients treated in the past for swallowed bones.

It became apparent that it would be necessary to collect one's own information from new cases seen as they came complaining of having swallowed bones. Over a period of two and a half years a total of 335 cases were seen. They were all interrogated and examined according to a definite scheme and the results of treatment were catalogued.

The data accumulated from these cases is presented and analysed. During the past year the conclusions drawn from this analysis were put into practice with an encouraging degree of accurate diagnosis and successful treatment.

PART 2.

THE HISTORICAL ASPECT OF SWALLOWED FOREIGN BODIES.

THE HISTORICAL ASPECT OF SWALLOWED FOREIGN BODIES

It is reasonable to believe that ever since man turned from "apples to animals" in the Garden of Eden, he has been the victim of swallowed bones assuming that he fragmented the bones and ate the fish unfilleted. No early writings of such misadventures are available but countless individuals must have suffered and died as the result of impacted bones in the oesophagus.

All the accidents of ingestion have by no means involved single bones. In the anatomical museum of Edinburgh University there is preserved a whole fish eight inches long and two and a half inches broad, which caused the death of a fisherman during the last century. The man was in a boat drawing in a net and, having his hands engaged, he seized the fish between his teeth to prevent its escape. A convulsive effort carried it down his throat and the fisherman died before the boat reached the shore. At autopsy the head was found within an inch of the gastric cardia

Grudger (1926) collected thirty-one instances of lodgement of live fish in the air and food passages. In none of these was an attempt made to remove the intruder by endoscopic means. However, more recent reports from central Africa and

India show an improving prognosis for these unfortunate fishermen whose habit it is to hold small live fish in their mouths while preparing the hook for live baiting. The most recent of these is by Rao(1954) from Kurnool, South India, who reports the removal of a four-inch, live fish from the left main bronchus of a fourteen year old Indian boy.

Prior to the advent of Gross during the middle of the last century, oesophageal foreign bodies were pushed down into the stomach with some form of bougie. Gross advocated the use of curved forceps, blunt metallic hooks, a piece of wire in the shape of a noose. Alternatively, a gum elastic catheter furnished with a stylet or piece of sponge or linen ball attached to its lower extremity, was used. Some ingenious instruments were devised, notably the Gross probang and the Graefe coin-catcher. These devilish devices were passed blind as this was still the pre-endoscopic era. Moreover their use was not confined to a specialty as we are told by Miller (1919) who relates the work of Horace Green and his probang. Horace Green was the Professor of Medicine at the New York Medical College.

Adelman (1884) reports the case of a man on whom the coin-catcher was passed to relieve him of a swallowed mutton bone. The instrument was passed below the bone but became so

tightly wedged that it could not be withdrawn. The unfortunate patient remained with this additional foreign body in his gullet for more than two days. The coin-catcher was finally loosened by means of a gum elastic catheter which was threaded over it. When the impacted instrument had been retrieved, the original foreign body was pushed into the stomach. The patient died about fourteen days later but, quoting Adelman, "it does not seem that the fatal result was in any way caused or accentuated by the surgical mishap".

Diggle (1932) writing half a century later says, "Blind use of the coin-catcher, bristle probang or bougie as an aid to diagnosis or as a means of treatment is to be deprecated as I am convinced that their use has resulted in more deaths from trauma and oesophageal perforation than lives saved."

Occasionally kneading was resorted to. In a case in which a patient was threatened with asphyxia through the impaction of several large pieces of potato in the oesophagus, Dupuytren managed to pinch the gullet with his fingers through the neck so as to crush the potato and thereby enable it to be swallowed.

This highly dangerous era of "unguided missiles" gave way to attempts at visualising the interior of hollow organs accessible from the exterior.

The passage of a tube into the oesophagus or stomach was inspired by sword swallowers. The attempt to visualise the oesophagus is credited to Bozini of Weimar who began his experiments in 1795 and several years later reported that he was able to see the upper end. Then followed Fisher of Boston in 1824, Segales of Paris in 1826, and John Avery of London about 1848 who all devised primitive endoscopes, mainly for the direct examination of the urinary bladder, vagina or rectum. None of them seems to have achieved practical success with such instruments and the pioneer of practical endoscopy must be looked upon as Desormeaux of Paris in 1853. This however was still not oesophagoscopy. Kussmaul of Freiburg in 1868, using the urethroscope of Desormeaux, was the first to perform oesophagoscopy. He employed a sword-swallower in his demonstrations and used the sword-swallowing position.

In 1881, Von Mikulics of Vienna who was familiar with Kussmaul's experiments, designed a practical oesophagoscope

illuminated by means of an interior platinum wire. Up to this stage the source of illumination had been a candle the light of which was reflected down the tube by mirrors and later intensified by systems of double convex lenses.

Bronchoscopy could quite aptly be called an accident of oesophagoscopy. The pioneers of oesophagoscopy believed that if a rigid tube could be passed into the oesophagus, it might also be passed into the larynx and trachea and on one occasion Rosenheim actually passed his oesophagoscope into the trachea by mistake. He was able to see the bifurcation but failed to appreciate the significance of his error.

In 1897 Killian removed a piece of bone from the right main bronchus of a man aged sixty-three years. This is probably the first actual removal of a foreign body from the lower air passages with an endoscopic tube.

At this time Einhorn of New York published the first article there on oesophagoscopy and in 1902 introduced the idea of the auxiary tube in the wall of the oesophagoscope as the light carrier. This marks the first employment of a distally illuminated tube.

Logan Turner of Edinburgh (1902) and E.B. Waggett of London (1903) were the first in Britain to practise direct oesophagoscopy.

Subsequent to this, Ingals, Jackson and Mosher in America utilized the Einhorn arrangement for distal illumination. Ingals in 1904 reported the removal of two foreign bodies using the Killian tube.

It is difficult to determine exactly to whom the credit is due for the invention of these tubes. Killian is credited as the one who first did successful work in bronchoscopy. The idea of using a tube, however, was not his for this work had been investigated by Kussmaul. Killian discovered and made known the fundamental work of Kussmaul who did not publish an account of his studies, as a result of which he did not receive the credit and Killian did.

To Chevalier Jackson of Philadelphia must be given the credit for improving the instrumentarium and bringing it to its present high state of perfection. He developed the largest school and clinic of peroral endoscopy on either side of the Atlantic. He was appointed the first Professor of Bronchoscopy and Oesophagoscopy at the University of Pensylvania. He made peroral endoscopy an important branch

of medical science, popularised the method among the medical profession and also made them "foreign body conscious".

PART 3.

THE ANATOMY OF THE OESOPHAGUS

AND

PHYSIOLOGY OF DEGLUTITION.

THE ANATOMY OF THE OESOPHAGUS AND PHYSIOLOGY OF DEGLUTION

EMBRYOLOGY

The primitive foregut develops as a diverticulum from the anterior end of the yolk sac to end blindly at the bucco-pharangeal membrane. The foregut comes to lie dorsal to the developing heart tube and to the septum transversum. It is embedded in visceral mesoderm and there is no true mesentery. The bucco-pharangeal membrane ruptures and the ectodermally lined stomatodeum becomes continuous with the foregut.

The oesophagus lengthens rapidly at the time of the caudal migration of the developing heart and respiratory systems and at the same time there may be a temporary obliteration of the lumen. The obliteration has been denied by some recent investigators. The oesophageal endodermal lining is at first of the columnar type but gradually becomes of the stratified squamous variety. There is some doubt as to the origin of this epithelium. It may become stratified squamous by metaplasia of the existing cells, or there may be migration of cells from the buccal cavity. The smooth muscle fibres develop

from the visceral mesoderm but the origin of the striated muscle, which is found in the middle and upper portions of the tube, is still in doubt.

DESCRIPTIVE ANATOMY

The oesophagus extends from the lower border of the cricoid cartilage at the level of the sixth cervical vertebra, to the cardiac orifice of the stomach at the side of the body of the tenth or eleventh thoracic vertebra. In the newborn infant the upper limit of the oesophagus is found at the level of the fourth or fifth cervical vertebra and inferiorly it terminates at the level of the ninth thoracic vertebra.

The oesophagus varies in length from 23 to 28 centimetres (average 25 centimetres) in the adult. At birth it is approximately 8 to 10 centimetres long and at the end of the first year it has increased to 12 centimetres. Between the first and fifth years it reaches a length of 16 centimetres The increase from the fifth year until puberty is slow as the oesophagus measures only 19 centimetres by the fifteenth year.

The greatest diameter of the empty oesophagus is

about 20 millimetres. When distended, however, it may be as much as 30 millimetres. At birth the diameter is about 5 millimetres but this diameter almost doubles in the first year and by the age of 5 years, it has attained a diameter of 15 millimeters. The diameter of the oesophagus is not uniform throughout its length. It has three constrictions, upper, middle and lower with slight elongated dilatations between them. The upper constriction is at the commencement immediately below the cricoid cartilage. The middle one is found where the oesophagus is crossed by the aorta and left bronchus and the lower one where the oesophagus pierces the diaphragm. This classic description of distinct narrowings of the oesophagus is given in almost all anatomy books and Callander (1945) in his Surgical Anatomy goes on to mention that the second narrowing is a special site for the arrest of foreign bodies. This, as will be shown later, cannot be accepted as correct. The uppermost "narrowing" is by virtue of the tone of the cricopharyngeal sphinctre and just below this, pressure from without by the crowding of several structures into the upper thoracic aperture. This is the special site for the arrest of foreign bodies.

The course pursued by the oesophagus is not straight from its origin to its termination, but shows three

curves. One lies in the sagittal plane, the other two are in the coronal plane. The sagittal curve is the most prominent and runs parallel with the contour of the anterior aspect of the vertebral column as far as the seventh thoracic vertebra. Beyond this point the oesophagus comes forward to lie in front of the descending thoracic aorta. The first of the coronal curves which has a slight amplitude to the left, begins a little below the commencement of the oesophagus and ends where the oesophagus reaches the middle line at the level of the fifth thoracic vertebra. This curve is therefore found in the lower part of the neck and the upper part of the thorax. At the point of maximal deflection of the curve, the oesophagus projects 4 - 6 millimetres beyond the left margin of the trachea. The second coronal curve is formed by a bend to the left as the abdominal part of the oesophagus passes to the left to enter the stomach.

STRUCTURE

The wall of the oesophagus has four layers. From without inwards these are the fibrous, muscular, submucous and mucous layers.

1. FIBROUS LAYER

This forms a loose covering which allows the oesophagus to move freely on the adjacent structures and is responsible for the rapid spread of perioesophageal infection.

2. MUSCULAR LAYER

This is composed of an outer longitudinal and an inner circular coat. In the upper part of the oesophagus, the two coats are well developed but are not clearly defined. The longitudinal coat is as thick as the circular coat except posteriorly at the beginning of the oesophagus. Here the longitudinal coat diverges forward fo become attached to the posterior surface of the cricoid cartilage and so provides a potentially weak area for the development of oesophageal diverticula.

The circular coat is continuous above with the inferior constrictor of the pharynx and below with the circular and oblique muscle layers of the stomach. According to Whillis (1951), quoted by Scott-Brown, there is no histological evidence of a cardiac sphincter at the lower end of the oesophagus in man. The sphincter action will be discussed later.

The muscle fibres of both coats of the upper third of the oesophagus are striated, becoming progressively replaced by smooth muscle in the middle third and being entirely smooth muscle in the lower third.

3. SUBMUCOUS LAYER

This is composed of connective tissue and elastic fibres containing the deep part of the oesophageal glands. Together with the muscularis mucosae, the submucous layer forms longitudinal folds in the lumen of the oesophagus providing recesses in which foreign bodies may be missed by the endoscopist.

4. MUCOUS LAYER

The mucous membrane is composed of non-cornified stratified squamous epithelium continuous with the mucous membrane of the pharynx above, but paler. At the gastro-oesophageal junction it is abruptly succeeded by the columnar epithelium of the stomach.

OESOPHAGEAL GLANDS

These are of two types :

(a) Mucus secreting tubulo-alveolar glands, penetrating into

the submucosa. The ducts connecting the glands with the lumen of the oesophagus are for a short distance from the lumen, lined with stratified squamous epithelium.

(b) Cardiac glands situated at the upper and lower parts of the oesophagus but these do not penetrate the muscularis mucosae. They resemble cardiac glands of the stomach, some containing typical zymogenic cells. Some investigators consider these to be areas of heterotopic gastric mucosa.

RELATIONSHIPS OF THE OESOPHAGUS

The oesophagus is separated from the vertebral bodies and intervertebral discs by the anterior longitudinal ligament and longus cervicis muscle covered by the prevertebral fascia. Below the level of the seventh thoracic vertebra, the aorta passes behind the oesophagus and lower down forms a right relation to it.

The thoracic duct lies adjacent to the right side of the lower part of the oesophagus up to the level of the fifth thoracic vertebra, where it passes behind the oesophagus to form a left relationship. The azygos vein lies to the right

of the thoracic duct until the latter crosses the midline. The upper five right intercostal arteries pass from left to right behind the oesophagus.

The trachea lies in front of the oesophagus as far as the fifth thoracic vertebra and below this, the left main bronchus and right pulmonary artery indent the anterior wall of the oesophagus. Due to the first coronal curve of the oesophagus, it projects from below the posterior surface of the trachea and for this reason, the left recurrent laryngeal nerve lies on the anterior aspect of the oesophagus while the right recurrent laryngeal nerve ascends in the oesophageal sulcus.

The tracheo-bronchial lymph glands are interposed between the oesophagus and the bifurcation of the trachea but below this level, the anterior aspect of the oesophagus is covered by the left atrium and pericardium. At this level the inferior vena cava lies to the right of the oesophagus with the thoracic duct and azygos vein interposed between them. As the oesophagus pierces the diaphragm, the decussating fibres of the crura envelop it anteriorly as they enter the central tendon of the diaphragm and it lies first on the right crus and then on the

left crus of the diaphragm. In the abdomen, the oesophagus grooves the upper part of the left lobe of the liver.

The lateral lobes of th thyroid, the carotid sheaths and their contents and the oesophageal branches of the inferior thyroid arteries form lateral relationships to the cervical oesophagus.

In the upper thoracic part of its course, the oesophagus is related on its right side to the mediastinal pleura which separates it from the right lower lobe behind the hilum of the lung, pulmonary ligament and the arch of the azygous vein which passes above the root of the lung to join the superior vena cava. On the left side, the left lung is separated from the oesophagus by the pleura, subclavian artery and thoracic duct. The arch of the aorta passes backwards above the root of the left lung to become continuous with the descending aorta.

The vagi nerves are intimately related to the oesophagus in the posterior mediastinum. Posterior to the root of the lung, each nerve breaks up to form the posterior pulmonary plexus from which two nerves arise and pass to the

oesophagus. The nerves of each side subdivide and communicate with each other to form the oesophageal plexus. As the oesophagus leaves the thorax each nerve again becomes reconstituted, the left passing in front of the oesophagus and the right behind it, to become the anterior and posterior gastric nerves.

BLOOD SUPPLY.

The arteries arise from the inferior thyroid arteries in the neck, the descending aorta in the thorax and the left gastric artery in the abdomen. Additional vessels come from the left phrenic artery.

An extensive venous network forms on the surface of the oesophagus and drains into the inferior thyroid veins and the azygous system. At the cardia many thin-walled submucosal veins connect the oesophageal veins with the gastric veins. In portal obstruction, this anastomosis between portal and systemic systems, frequently becomes varicose.

LYMPHATIC DRAINAGE.

This is composed of two networks of capillaries,

one in the mucous layer continuous above and below with those of the mucosa of the pharynx and stomach respectively. The second network of capillaries is present in the muscular coat and drains by the same vessels as the mucous capillaries into the paratracheal, lower deep cervical, tracheo-bronchial, posterior mediastinal or left gastric glands. The drainage is not necessarily regional as the vessels may pass up or down under the mucosa before draining into distal lymph glands.

PHYSIOLOGY OF DEGLUTITION

The primary function of deglutition in man is the transfer of solid and liquid food from the buccal cavity to the stomach.

The act of swallowing is a complex, co-ordinated reflex action which is usually initiated voluntarily but is for the most part completed as an orderly sequence of reflexes. It is described in three stages, buccal, pharyngeal and oesophageal but completion of the first stage inevitably involves the automatic completion of the whole process.

1. Buccal Stage.

This is the voluntary stage in which the bolus of food is propelled from the mouth, through the fauces, into the oropharynx.

Solids. Solid food, after mastication and lubrication with saliva, is moulded into a bolus between the tongue, cheeks and hard palate, and collected on the dorsum of the tongue preparatory to swallowing. The lips are closed and the buccinator muscles compress the cheeks against the teeth. The bolus is forced backwards by the elevation of the floor of the mouth and at the same time the tongue contracts and moves backwards. The anterior part of the tongue is pressed against the hard palate, then the posterior part of the tongue is drawn backwards by the action of the intrinsic muscles of the tongue - hyoglossus and styloglossus. The floor of the mouth is raised mainly by contraction of the mylohyoid muscles. The backward movement of the tongue forces the bolus through the oropharyngeal isthmus and temporarily obliterates the lumen of the oropharynx. At the same time, the isthmus of the fauces is narrowed by the contraction of palatoglossus muscles approximating the faucial pillars.

Fluids. The swallowing of fluids occurs in two phases. In the first phase, with the mouth closed, the tip of the tongue is brought against the hard palate just behind the incisive papilla. Then the upper surface of the tongue is moulded to form a longitudinal groove forming a tubular space with the palate and contains the fluid. The margins of the tongue are pressed against the lingual surface of the upper gums. The dorsum of the tongue is next forced upwards, commencing at the tip and extending backwards. This obliterates the tubular space and squirts the fluid backwards into the oropharynx.

In the second phase, the teeth are brought into apposition and the mylohyoid muscles contract, forcing the posterior part of the tongue backwards, pushing the fluid into the laryngeal part of the pharynx. This second phase is therefore comparable to the swallowing of solids.

2. Pharyngeal Stage.

In this stage the food passes through the pharynx to the upper end of the oesophagus. As the pharynx is common to both respiratory and alimentary passages, the act of swallowing is accompanied by closure of the nasal,

oral and laryngeal openings into the pharynx. These openings are provided with sphincteric mechanisms.

Closure of the Nasopharyngeal Opening.

The nasopharyngeal aperture is closed by the co-ordinated action of several muscles. The levator palati muscles pull the soft palate upwards and backwards towards the posterior pharyngeal wall. The tensors of the palate depress its transverse arch (and open the ostia of the pharyngo-tympanic tubes). At the same time the palato-pharyngeus muscle contracts and acts as a sphincteric mechanism of the nasopharyngeal hiatus. This raises a rounded ridge on the posterior pharyngeal wall against which the upper surface of the soft palate makes contact. Thus the passage of food into the nasopharynx is prevented.

Closure of the Oropharyngeal Opening.

This is achieved by the contraction of the lingual muscles keeping the tongue against the palate, and the sphincteric action of the palato-glossus muscle preventing the bolus from passing back into the mouth.

Closure of the Laryngeal Opening.

This is effected in the following ways :

(a) Respiration is inhibited during the second stage of swallowing.

(b) The larynx is forcibly elevated into the shelter of the backward projecting base of the tongue by the action of the stylohyoid, stylopharyngeus, digastric and mylo-hyoid muscles. The thyro-hyoid muscle also assists in pulling the thyroid cartilage upwards.

(c) Closure of the laryngeal aditus is effected by contraction of the aryepiglottic muscles (sphincteric action) and lower down by the contraction of the thyroarytenoid and interarytenoid muscles approximating the arytenoids, and finally by the action of the lateral crico-arytenoid muscles approximating the vocal cords.

(d) The function of the epiglottis is not certain. It does not, as previously thought, flap down and guard the laryngeal aperture. It remains upright and appears to divert swallowed fluids through the pyriform fossae on e either side of the laryngeal aperture.

Pharyngeal Peristalsis and Elevation of the Pharynx.

The bolus of food traverses the pharynx very rapidly.

The pharyngeal musculature acts in two functional groups :

(a) The vertically disposed elevator group of muscles - stylopharyngeus, palatopharyngeus and elevators of the hyoid bone and larynx, decrease the vertical length of the pharynx and so draw it up over the bolus of food. This is followed by contraction of the middle and inferior constrictor muscles propelling the bolus to the upper end of the oesophagus.

3. Oesophageal Stage.

This stage involves the passage of food through the oesophagus into the stomach.

The pharyngeal end of the oesophagus is guarded by the crico-pharyngeal sphincter which is formed by the lowest fibres of the inferior constrictor of the pharynx arising from the cricoid cartilage. This sphincter is normally in a state of tonic contraction, preventing the sucking of air into the oesophagus by the negative thoracic pressure during inspiration. Likewise, without relaxation anaesthesia, it presents an obstacle to the passage of an oesophagoscope.

The crico-pharyngeal sphincter has a double autonomic nerve supply. Post-ganglionic sympathetic fibres are derived from the superior cervical ganglion. Parasympathetic vagal fibres reach the muscle in the recurrent laryngeal nerve. The crico-pharyngeal sphincter is inhibited when the main part of the inferior constrictor contracts in the reflex response constituting the pharyngeal stage of deglutition. Thus the arrival of the bolus is preceded by relaxation of the tonically contracted crico-pharyngeal sphincter. Failure of relaxation of this sphincter may be an important aetiological factor in production of pharyngeal diverticula.

Oesophageal Peristalsis.

The bolus is passed down the oesophagus by co-ordinated waves of peristalsis in which the oesophageal musculature relaxes just ahead of the bolus (which has been "stream-lined" in the mouth and pharynx) and at the same time contracts vigorously just behind it. Work by Alvarez (quoted by Samson Wright) makes it improbable that a wave of relaxation regularly precedes a wave of contraction.

Passage through the upper part of the oesophagus is very rapid on account of the initial momentum imparted to the

bolus by the pharynx and the suction effect exerted by the negative pressure of the thorax. Standard works describe rapid peristalsis in the upper third of the oesophagus and explain the rapidity on the grounds of striated muscle being capable of more rapid contraction and relaxation than smooth muscle.

Three types of contractions are described :

1. Primary contraction wave. This is a rapid, propulsive contraction wave occurring in the upper third of the oesophagus but initiated in the pharynx.

2. Secondary contraction wave. This is similar to the slow, rhythmical peristalsis of intestine and occurs in the lower half of the oesophagus. It is initiated by local intramural distension.

3. Tertiary contractions. These occur in the lower third of the oesophagus, are inco-ordinate and do not contribute to propulsion of the bolus. These are similar to the "mixing contractions" of intestine.

Gravity does not play an important part in the

passage of a bolus through the normal oesophagus.

"Cardiac Sphincter"

It is now more generally accepted that there is no true sphincter at the lower end of the oesophagus but that sphincteric action is contributed by the diaphragmatic hiatus. In addition, the negative intrathoracic pressure tends to retain fluids and solids in the lower end of the oesophagus. Fluids enter the stomach in a more or less steady stream and solids enter intermittently.

NERVOUS REGULATION OF DEGLUTITION

The orderly sequence of muscular responses which constitute the act of swallowing is reflex in origin.

The sensory receptors from which the reflex can be most readily evoked are concentrated mainly in the mucosa of the posterior pharyngeal wall, anterior and posterior faucial pillars and the base of the tongue.

The afferent pathways of this reflex arc are fibres of the nerves innervating these areas. These are the glossopharyngeal nerve, the pharyngeal and internal laryngeal branches of the vagus and the trigeminal nerve.

A deglutition centre is located in the medulla close to the vagus nucleus. It may be regarded as a co-ordinating and distributing centre. The afferent impulse stream is relayed from the deglutition centre in orderly timed sequence along association fibres to the appropriate motor neurones supplying the muscles involved in reflex swallowing. The deglutition centre is in close relationship with the respiratory centre which is inhibited during swallowing.

The efferent motor fibres are mainly in the hypoglossal, spinal accessory, vagus (pharyngeal and laryngeal branches), glossopharyngeal and trigeminal nerves. The efferent impulses are mediated through these nerves to the muscles of the tongue, fauces, palate, pharynx, larynx and oesophagus concerned in the reflex stages of deglutition.

The orderly progress of the peristaltic wave in

the upper oesophagus is part of the reflex response excited by the initial stimulation of the receptors in the pharynx. Thus upper oesophageal peristalsis is dependent upon the integrity of the vagal oesophageal plexus. Therefore, a foreign body lodged in the upper oesophagus does not give rise to peristalsis. This has to be initiated afresh in the pharynx.

The bolus of food itself causes a series of weak reflex contractions by local stimulation of sensory nerve endings in the oesophagus but this mechanism is of secondary importance in the upper oesophagus. In the lower oesophagus, however, which is composed of smooth muscle, the wave of peristalsis is independent of the extrinsic nerve supply and the deglutition centre. Here co-ordination of peristalsis is dependent upon the intramural myenteric plexus.

PART 4.

THE ANALYSIS OF THREE HUNDRED AND THIRTY-FIVE CASES OF SWALLOWED BONES.

ANALYSIS OF THREE HUNDRED AND THIRTY FIVE CASES OF SWALLOWED BONES

During a period of two and a half years, 335 cases in all came to Groote Schuur Hospital complaining of having swallowed bones. This hospital class of patient was drawn from all races throughout Cape Town and the surrounding districts, from as far afield as border towns of the Cape Province and on one occasion, from South West Africa. For this reason, it is impossible to estimate the incidence per unit population. During the same period 22,591 cases attended the Ear, Nose and Throat Outpatients Department, i.e. one patient in 67 complained of having swallowed a bone.

According to Macmillan (1935) who did a statistical study of diseases of the oesophagus, foreign bodies accounted for 30% of all dysphagias. Dysphagia was the complaint of one case in 161 attendances in the outpatients department of the Massachusetts General Hospital; thus one in 536 attendances were for swallowed foreign bodies.

The number of patients attending Groote Schuur Hospital, having swallowed foreign bodies other than bones, is very small. Their problem is an entirely different and simpler one. The record of these has not been included in this series.

There is a definite seasonal incidence of at least one type of swallowed bone - that of the snoek which is caught in large numbers during Winter.

Various writers claim that the incidence of swallowed foreign bodies is particularly high amongst mental patients and prisoners. Here, experience with mental patients has been similar to that of Korkis (1952). The mentally disordered prefer more solid articles ranging from coins to cutlery and bones are uncommon. Of the thousands of prisoners in Cape Town, only one contribution to this series was made but this indeed was the largest of all beef bones removed.

RACE INCIDENCE.

Of the total number of patients seen, 59% were Non-European and 41% were European. These figures are probably

of no real significance as one has no estimate of the number of patients (predominantly European) who consult private doctors and who are treated in nursing homes. It would however seem that the incidence among Europeans is higher than among Non-Europeans, considering the distribution of these races in the general population. One possible explanation to this might be found in the price of dentures (to be discussed later).

AGE INCIDENCE.

The youngest patient treated was six months of age and the oldest was 89 years. There was a surprisingly large number of children under the age of ten years - 22 cases. This number was approximately doubled in the 11 - 20 years group and again approximately doubled for the 21 - 30 year and the 31 - 40 year age groups. Thereafter there is a progressive decline in numbers with increasing age as indicated in Fig. 1.

According to Gladys Boyd (1951), coins constitute 50% of foreign bodies in children under 2 years of age and

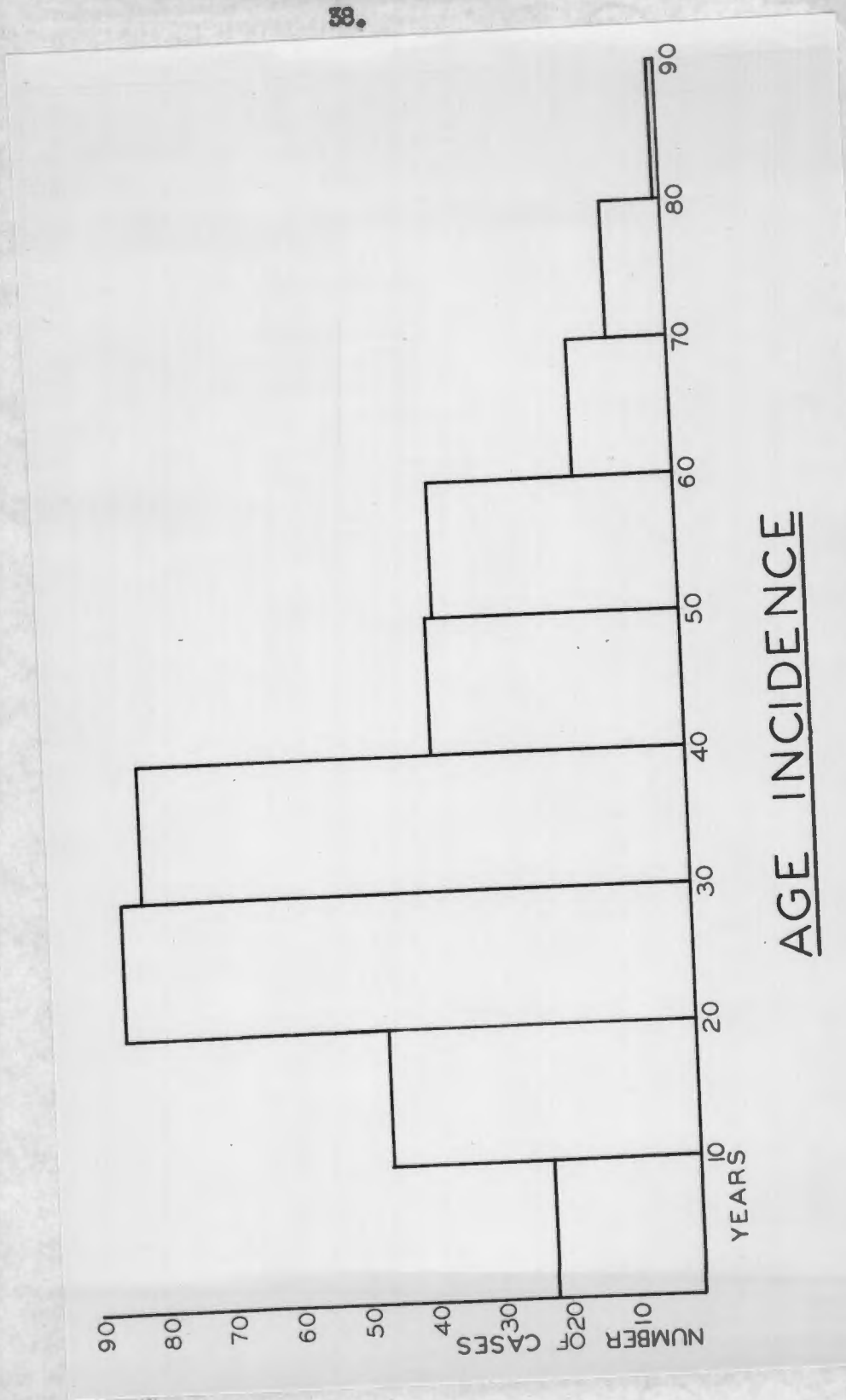


Fig. 1

fish bones only 5%. The experience at Groote Schuur Hospital is that bones are at least as common as coins in this age group.

SEX INCIDENCE.

Females constituted 59% of patients seen and males 41%. Considering that the ratio of males to females is approximately equal in the general population, these figures are a true reflection of sex incidence. No satisfactory explanation to this has been found. Only a few more than half of the patients wearing dentures were females. As the majority of patients were in the 20 - 40 year age group, as shown in Fig. 2, one might suggest that these were the mothers of families which claimed so much of their attention at meal times that they were unable to detect the bones in their own food until it was too late. An account of such distraction at the time of swallowing a bone was given by some patients.

TYPES OF BONES SWALLOWED.

The following types of bones were swallowed.

(See Fig. 3).

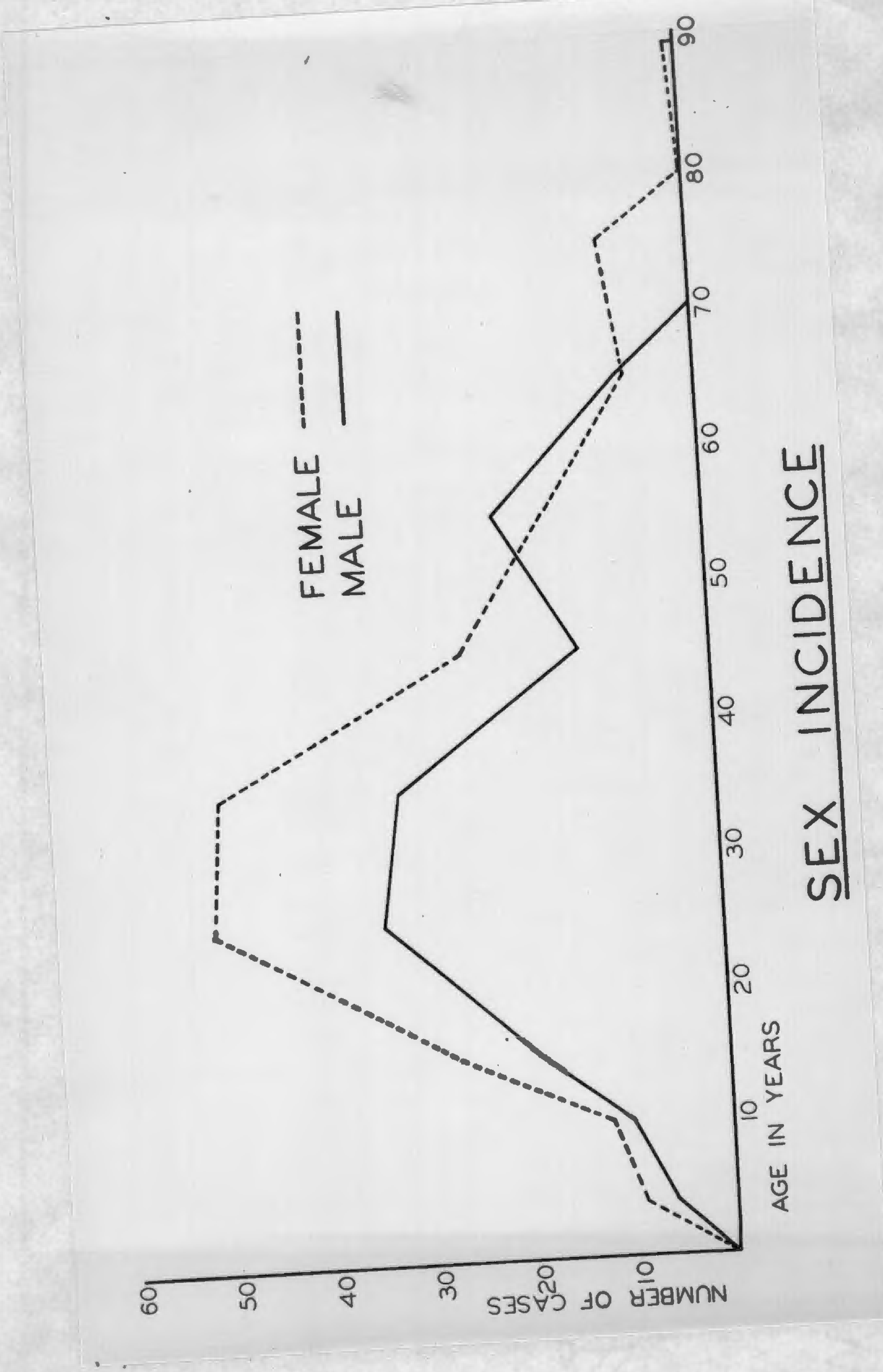

SEX INCIDENCE
FEMALE
MALE
NUMBER OF CASES
10
20
30
40
50
60
AGE IN YEARS
10
20
30
40
50
60
70
80
90

Fig. 2

GENERAL ANALYSIS OF 335 SWALLOWED BONES

131 BONES REMOVED ie. 39%

TYPE OF BONE	FISH	MEAT	CHICKEN
ACTUAL NUMBER	217	91	27
RELATIVE NUMBER	64%	27%	8%
NUMBER REMOVED	61	54	16
% REMOVED	28%	59%	59%
IN OESOPHAGUS	29%	100%	75%
ABOVE OESOPHAGUS	71%	0%	25%

GENERAL ANAESTHETICS 89
MORTALITY 2 (cardiac arrest)

FIG. 5

(a) Fish Bones.

These formed 64% of all the bones swallowed. The preponderance of fish bones over meat and chicken bones is due to the fact that fish is the cheapest of the three articles of diet and at one time meat was very difficult to obtain, irrespective of price.

In inverse proportion to the number of fish bones swallowed, is the comforting fact that, of the three types of bones, a smaller percentage (28%) of fish bones swallowed, required removal than either meat or chicken bones swallowed.

The types of fish involved include almost all the common varieties eaten - kippers, stockfish, red roman, red stumpnose, maasbanker, kingklip, elf, pilchard, sole, hottentot, geelbek, kabbeljou, snoek. Very often the patient is unaware of the type of fish eaten. The significance of the type of fish is that snoek bones, by virtue of their greater size and rigidity, behave more like meat bones, requiring removal twice as frequently as any other type of fish bone swallowed.

No whole fish were removed and even the finding of two bones was exceptional.

(b) Meat Bones.

These formed 27% of all bones swallowed but in contrast to the fish bones, a much greater number (59%) required removal. The types of meat bones swallowed included mutton, beef, pork, veal and various forms of game.

(c) Chicken Bones.

These constituted the smallest group of all bones swallowed (8% of the total) and required removal as frequently as meat bones, i.e. 59% of meat bones swallowed and 59% of chicken bones swallowed, required removal. It is interesting to note that according to Flett (1945), the commonest type of bone swallowed in America, is the chicken bone.

REASONS FOR SWALLOWING BONES.

Clerf (1940) cites carelessness in the preparation and eating of food as an important aetiological factor.

It is interesting to note that in the vast sheep-farming areas of this country, the incidence of swallowed meat bones is very low indeed. The suggested explanation to this is that in the country meat is "slaughtered" with a knife and prepared in large sections. In the city, meat is "butchered" with an axe and sold in smaller portions.

Carelessness in the preparation of food (meat, fish or chicken) is undoubtedly an important factor in bones swallowed by the lower age groups. These young children of under four years of age (fourteen in this series) should be given food free of bones.

Fish and chicken served to adults can hardly be prepared free of bones of dimensions likely to cause trouble. Stews are always a potential danger. Older children should be instructed in the care necessary to avoid swallowing bones.

This leaves the category of patients who, in spite of all precautions, still swallow bones. As has been shown, females outnumber males by 18% and as these are predominantly in the 20 - 40 year age group, it might be suggested that

many of these are mothers of children who claim or distract their attention at meals. Patients sometimes give the hurried gulping of food as the reason for their mishap.

Dentures.

These were found to be worn by only a few more females than males but not sufficient to account for the 18% difference between the two sexes.

It is apparent from the records that dentures in the Non-European patients are rare and in the European patients, relatively common. The obvious explanation for this is economic and not a better state of dentition in the Non-European. In the 20 - 40 year age group, dentures were found in 38% of the Europeans but estimates of the incidence of dentures in the 20 - 40 year age group among the general European population vary so greatly as to invalidate any comparison. The wearing of dentures is, however, quoted by several writers as a predisposing factor in the swallowing of bones. Anyone wearing an upper denture is deprived of palatal sensation and therefore more likely to swallow a bone lying in the upper part of a bolus of food when this is compressed between the tongue and the

palate. The bone is swallowed and its presence detected in the pharynx but this is too late as the reflex mechanism of deglutition carries it down into the oesophagus.

SITES FROM WHICH BONES WERE REMOVED.

Of the three hundred and thirty five patients who complained of having swallowed bones, from only 131 or 39% were bones actually removed. The sites where these bones were found conform roughly to a pattern depending upon the type of bone swallowed. Of the fish bones, 71% lodged in any area from the tongue to just above the crico-pharyngeal sphincter. The remaining 29% were removed from the oesophagus.

In contrast to this, every meat bone removed was found in the oesophagus.

The chicken bones behaved much like the meat bones, with 75% being recovered from the oesophagus and 25% from above the oesophageal opening.

Thus one is able to predict with some degree of

certainty the likely situation of a particular type of bone once the symptoms suggest that the bone is still in situ.

Of the bones which impact in the supraoesophageal tissues, 16% are found in and around the tonsils. Some penetrate the base of the tongue or the post-pharyngeal wall to varying depths; a few are found in the pyriform fossae and most in the valleculae.

Of all the bones swallowed, only one was recovered from the larynx (to be discussed later).

BONES LODGED IN THE OESOPHAGUS.

Contrary to the teaching of most surgical textbooks that foreign bodies become arrested at the three classical sites of constriction, viz. upper, middle and lower, bones were seldom found below the upper third of the oesophagus.

The axiom that unusual foreign bodies stick at unusual sites, is true. The unusual foreign bodies are portions of dentures, toys, trinkets, open safety pins and any other unusual object which finds its way down the food channel. Usual foreign bodies are spicules of bone, small

portions of flat bones and coins.

The majority of bones which are removed from the oesophagus are found in the first fifteen centimetres. As the oesophagus commences fifteen centimetres from the upper incisor teeth, the total depth of the bone is seldom greater than thirty centimetres.

Pathological conditions of the oesophagus which predispose to the arrest of foreign bodies are fibrous strictures following corrosive trauma or surgery, neoplasms, pouches, webs, achalasia and neurological lesions resulting in paralysis of the oesophagus. Peele (1954) includes such extra-oesophageal conditions causing compression as goitre, aneurysm etc. No extraoesophageal conditions were found in this series. It was not uncommon to remove a bolus of meat from an intraoesophageal lesion but bones per se were never found. These patients seek advice for their dysphagia unassociated with the swallowing of a bone. In one elderly female from whom a bolus of meat was removed, haematological investigation was done as a result of the atrophic appearance of her gastric mucosa as seen through the oesophagoscope. She was found to be suffering from pernicious anaemia.

REASONS FOR THE ARREST OF BONES IN THE OESOPHAGUS

Some bones, by virtue of their size and shape, are incompatible with smooth passage through the normal oesophagus of limited dimensions. These are the large, flat, irregularly shaped bones which are liable to become lodged in the upper third or any other unusual site in the oesophagus. These bones generally do not impact in the mucosa at once. Due to respiratory and cardiac movements, they are apt to move down a little at a time before finally impacting in the mucosa. When lodged in the middle and lower third of the oesophagus, these bones, by virtue of their bulk, stimulate peristaltic action which further aggravates their impaction and penetration.

The usual slender, sharp bone, with or without a bolus of food, is propelled into the upper oesophagus with great force by the pharyngeal mechanism. It is driven into a fold of mucosa causing a puncture or lacerated wound and either passes on with the bolus of food or remains in situ. Once the mucosa has been damaged, the patient has pain which is usually worse on swallowing.

The upper oesophagus is a narrow channel, not by

virtue of its own dimensions, as this portion is just as distensible by an endoscope as any other part of the oesophagus, but for three other reasons :

(a) The crico-pharyngeal sphincter is a powerful muscle tonically contracted and, as all experienced endoscopists know, capable of making the withdrawal of a foreign body very difficult unless completely relaxed by anaesthesia. For the same reason this muscle prevents the foreign body from passing downwards. See Figs. 4 and 5, Pages 51 and 52. The former is a smoek bone within the crico-pharyngeal sphincter and the latter is a meatbone straddling the sphincter.

(b) The remaining portion of the upper oesophagus is rendered less easily distensible than the rest of the oesophagus by the crowding of structures around it. Posteriorly is the rigid vertebral column covered by muscles and anteriorly is the relatively rigid cricoid cartilage and trachea. For this reason, cross sections always show a flattened oesophagus from before backwards and flat bones and coins pass down in the coronal plane. Laterally are the posterior borders

Fig. 4.

Fish bones are seldom demonstrated on a radiograph. The above is a snoek bone gripped by the crico-pharyngeal sphincter. The opacity immediately anterior to it is calcification of the thyroid cartilage.

Fig. 5.

A meat bone, the density of which is greater than that of the vertebral bodies on account of "end-on" projection as it straddles the crico-pharyngeal sphincter.

of the lateral lobes of the thyroid gland and the carotid sheaths. At the rigid thoracic inlet, the oesophagus is "crowded out" by the trachea, common carotid and subclavian arteries plus the large veins of the neck, all packed into a small, indistensible compartment bounded anteriorly by the sternum and first ribs curving round to the vertebrae posteriorly. This "compressed area" of the oesophagus is a favourite site for the arrest of bones. It is definitely below the cricopharyngeal sphincter. Fig. 6 page 54 shows a large meatbone in this region, i.e. opposite the first thoracic vertebra. Fig. 7, page 55 demonstrates a bone which extends across both the sphincter and the "crowded out area".

(c) A third factor responsible for the retention of a bone in the upper oesophagus is its inability to initiate peristalsis in this part of the oesophagus. Such a stimulus must come from the pharynx. This may be a reason for the swallowing of a piece of bread which expedient however, is only effective if the bone is not impacted but it frequently drives the bone deeper

Fig. 6

A large meat bone arrested at the "crowded out" area below the cricopharyngeal sphincter. The adjacent air is due to the apices of the lungs in the supraclavicular fossae.

Fig. 7.

A meat bone extending from the cricopharyngeal sphincter to the "crowded out" area of the oesophagus.

into the mucosa. For this reason, the practice of using cotton wool soaked in barium sulphate in an attempt to demonstrate a bone radiologically, is considered unwise.

PART 5.

THE MANAGEMENT OF PATIENTS SUSPECTED OF HAVING SWALLOWED BONES

THE MANAGEMENT OF PATIENTS SUSPECTED OF HAVING SWALLOWED BONES.

This indeed was the problem which prompted the investigation into these unfortunate patients who come to hospital by day and by night seeking relief from their symptoms, the most dominant of which is pain. The assessment of these patients seems to constitute an equally great problem to the practitioners who refer them to Groote Schuur Hospital. Of the 335 patients, 66% were referred by letter from practitioners and other hospitals. Of all these cases referred by doctors, only 39% were found to have bones requiring removal.

Here, as in all branches of medicine where one is obliged to accept the patient's account of the symptoms and have few, if any signs to elicit on examination, one must assess carefully the type of individual in each case. A comparison of extreme examples of this is the stoical Native labourer who, one day after swallowing the bone, sacrifices a day's wages to attend hospital and on the other hand, the idle, neurotic European who rushes from her meal to consult the doctor within minutes of swallowing a bone. In spite of the fact that the

latter is more likely to wear dentures, she is the less likely to require removal of a swallowed bone.

DETERMINATION WHETHER FOREIGN BODY IS ALIMENTARY OR RESPIRATORY.

Symptoms at the time of swallowing the foreign body are of major importance. The layman will complain of having "swallowed" an object when he means to convey that it has been inhaled. The initial symptoms accompanying the swallowing of the foreign body must be sought by direct questioning in each case. Severe coughing, sufficient to bring tears to the eyes, breathlessness, wheezing and a blue discolouration in the face, are all important symptoms suggesting that the bone has been inhaled and in the absence of finding evidence that it has been swallowed, the air passages must be investigated.

It is not uncommon for a non-obstructive, inhaled foreign body to produce neither symptoms nor signs, clinical or radiological, between the initial symptomatology and the onset of complications, notably suppuration. Clerf (1952) quotes Gross,

writing just one hundred years ago, drawing attention to this cessation of symptoms after the initial cough and sense of suffocation. Today it is often difficult to convince parents and some doctors, of the responsibility to prove the absence of an inhaled foreign body in such circumstances.

It is comforting to note that in this series of bones, only one was removed from the trachea and this, possibly, was due to the finger of the anxious mother who attempted to remove a swallowed bone by passing her finger down the child's throat. That bones do find their way into the trachea and bronchi is certain, as evidenced by other cases not in this series.

Conversely oesophageal foreign bodies may produce respiratory symptoms in the following ways :

1. Aspiration of nasopharyngeal secretions due to an inability to swallow them.

2. Compression of the trachea causing strider and dyspnoea.

3. Spreading inflamation causing oedema of the larynx.

4. Ulceration with resultant oesophago-tracheal fistula.

Rashid (1950) published a typical case of a foreign body in the oesophagus (metal button) producing symptoms of respiratory obstruction by causing oedema of the anterior oesophageal wall, spreading to the posterior tracheal wall. The patient was able to swallow fluids.

PAIN.

The most important fact to realise about pain caused by a swallowed foreign body is that the symptom of pain does not necessarily mean the presence of a foreign body. Pain is due to the wound, either puncture or laceration, caused by the foreign body which may since have passed on. There is usually no immediate relief by the passage of a bone and the patient remains absolutely convinced of its presence as the severity of the pain remains unchanged. The literature studied does not stress these elementary points.

Two of the patients in this series were doctors. One was unwilling to accept the above explanation. So convinced was he of the presence of a bone, judging by his pain, that he demanded endoscopy. This was done and the usual superficial wound through mucosa only was found.

Onset of Initial Pain.

This must commence at the time of swallowing the bone. Some patients have complained of a pain which commenced hours or days after the alleged swallowing of a bone. Where this late pain was absolutely the first symptom and there were no complicating factors, e.g. having had a meal under the influence of alcohol, pain was not due to a swallowed bone.

Character and Severity.

This may be described in all degrees from a mild discomfort to an agonising constant pain from which the patient demands instant relief. The average patient complains of persistent pain, sharp in nature and definitely aggravated by swallowing. A traumatic lesion in the lower half of the oesophagus is mostly described as a burning or sharp pain in the epigastrium.

Localisation of Pain.

Bones are very rarely removed from patients who, when asked to point to the site of the pain, vaguely sweep the hand over the entire neck. On the other hand, painful lesions of the fauces, tonsils and base of tongue, are accurately localised. When the pain

is lodged in the valleculae or pyriform fossae, patients usually point to one or other side of the neck at the level of the thyroid cartilage.

Oesophageal pain, on the other hand, is localised with less certainty. The pain may radiate widely, depending on the severity of the stimulus. It may be felt over the precordium, epigastrium, shoulders, ear, face, neck, arm and hand. Generally the trauma of a bone in the upper third of the oesophagus produces pain in the suprasternal notch. A similar lesion in the middle and lower oesophagus, produces a burning pain in the epigastrium. An obstructive bolus in the middle third of the oesophagus rarely produces a sensation of substernal fullness or even cramp-like pain.

Accepting that the more widely radiated pain arises from a more severe stimulus, this pain has a special significance - penetration but not necessarily perforation of the oesophagus.

Pain accentuated by respiration does not necessarily mean involvement of the pleura but may be caused by fluctuations in the size of the lumen of the thoracic oesophagus due to the

varying intrathoracic pressure of respiration. Such rhythmical widening and narrowing of the oesophagus favours penetration of a sharp foreign body and so causes an accentuation of pain with respiration.

DYSPHAGIA.

Whether or not the patient finished the meal after swallowing the bone, is important. If the passage of the bone is prevented merely by its size without trauma, it will not cause sharp pain but is likely to be obstructive to the passage of food. More commonly the patient refuses to complete the meal on account of the accentuation of pain by swallowing. When patients relate that the food swallowed is returned, there is either a large obstructive bone or a small bone with adherent meat. Similar symptomology is produced by a bolus of meat impacted upon a pathological lesion of the oesophagus.

Patients usually manage to swallow their saliva in spite of the presence of a bone. When the saliva is not swallowed, there is either a total obstruction or an exquisitely

painful wound of the upper oesophagus which most likely contains a bone.

HAEMORRHAGE.

The production of a small amount of blood from the oesophagus or pharynx indicates trauma but not necessarily the presence of a bone.

INTERVAL BETWEEN MEAL AND EXAMINATION.

This interval varied between thirty minutes and one year. Generally the longer the interval, up to a maximum of seventy-two hours, the more significant are the symptoms. 78% of the patients arrived at hospital within 24 hours of swallowing the bone and in this group, only 40% required removal of a bone. In contrast to this, is the group seeking medical attention 48 to 72 hours after swallowing a bone. Bones were removed from 60% of these cases. Only 5 bones which had remained in situ for more than 72 hours were removed.

It has been stressed that the patient experiences pain aggravated by swallowing but is unable to determine whether the bone is still in situ. If the pain is due to trauma only, it improves daily after the first day. If there is absolutely no improvement in symptoms after one day, the bone is likely to be in situ and require removal.

For the bone to be present in those patients who consult the doctor after more than three days, there must either be symptoms and signs of inflamation or symptoms of obstruction. There are reports of many foreign bodies which have been removed from the oesophagus after a considerable period but these are not bones. Penetrating bones rapidly produce infection and impacted bones of any appreciable duration, produce ulceration and subsequent infection. Boyd (1951) reports on 35 patients with oesophageal foreign bodies which were removed within two weeks. These patients had no symptoms. The explanation to this is to be found in the fact that not one of the foreign bodies was a bone.

VINEGAR.

The evaluation of the symptoms thus far would indicate that those of importance are :

1. The inability to swallow on account of oesophageal occlusion.

2. Pain unchanged or increasing after the first twelve hours.

Unfortunately there is a common practice among South African patients which detracts severely from the value of persistent or increasing pain as a diagnostic feature in assessing the presence of a bone. This is the taking of vinegar in single or multiple doses in the belief that it will soften the bone and so facilitate its passage. No mention is made of this in the available English literature and one assumes, perhaps incorrectly, that it is not practised in other countries. The origin of this "home remedy" is obscure. Patients usually state that someone else volunteered the advice and the victim of a bone is only too eager to accept any advice. From the knowledge of the rapidity of deglutition, it is evident that the bone will not be bathed in vinegar long enough to remove the inorganic content. As an experiment, portions of slender snoek bones were immersed in vinegar and the process of softening observed. Brown discolouration occurs after twelve hours and softening only after 72 hours.

Neither discoloured nor softened bones have ever been removed from patients.

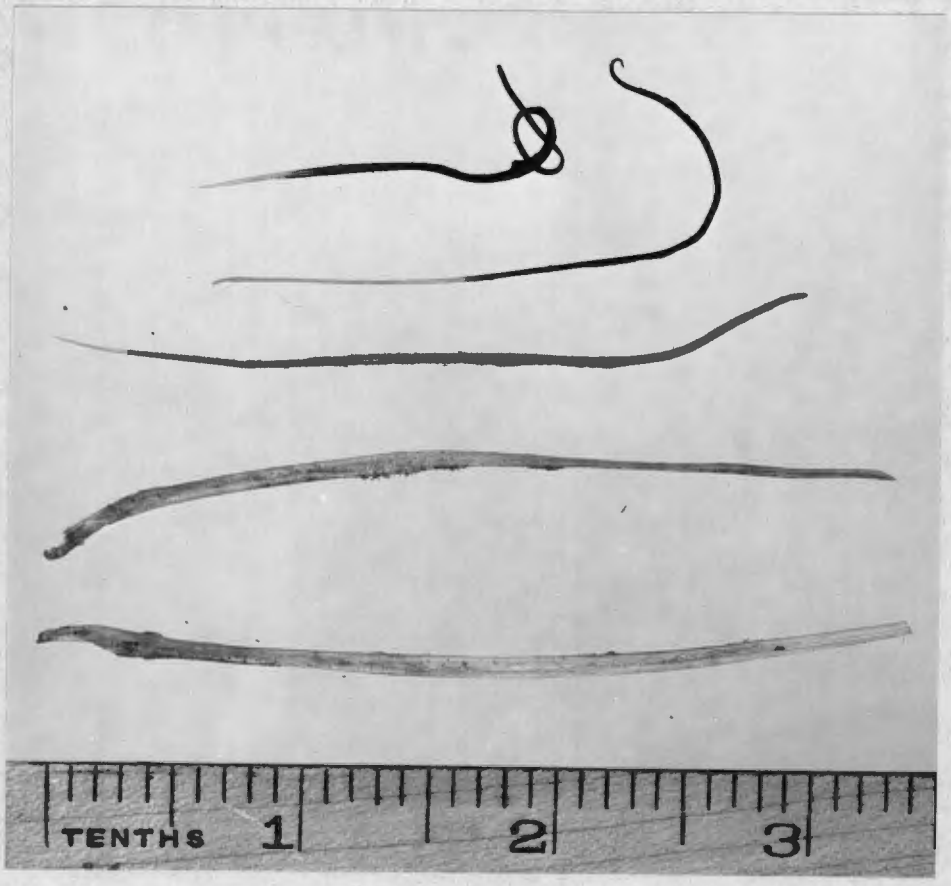


Fig. 8.

The above is a collection of large smoek bones. The blackened portions of the upper three bones indicate staining from immersion in vinegar. The two uppermost show softening after 72 hours immersion. The third one is discoloured only, after 12 hours.

The end result of this all too common practice of taking vinegar, is to confuse the otherwise reliable symptom of persistent or increasing pain. The wound caused by the bone develops a brisk chemical inflammation, the pain of which simulates the pain caused by the presence of a foreign body. Therefore, in these cases, persistent or increasing pain may be due to the presence of a bone, chemical inflammation or both.

EXAMINATION.

General : The generalised signs of inflammation (tachycardia, pyrexia, etc.) are not present within the first twenty-four hours unless the foreign body has penetrated deeply or the organisms concerned are particularly virulent.

Local : Localised pain and tenderness in the neck, to one or other side of the midline, between the cricoid cartilage and the suprasternal notch, indicates trauma. If in addition this pain is markedly accentuated by pressure on the tissues on the opposite side of the midline in the direction of

the painful area, the presence of a bone straddling the oesophagus must be suspected. See Fig. 5, page 52.

Obliteration of the normal anatomical landmarks of this region by oedema, indicates spreading infection and demands immediate antibiotic therapy in large doses..This sign is seldom found within twenty-four hours

The finding of surgical emphysema denotes perforation of the oesophagus either locally or lower down in the thorax from which it spreads upwards. See Fig. 16, page 85.

Peroral : Careful examination of the fauces, tonsils, base of tongue and hypopharynx, will reveal 71% of the fish bones requiring removal and 25% of the chicken bones . (see Fig. 3, page 41). This examination therefore, should be conducted with meticulous care as it may be rewarded with a positive diagnosis in which case no anaesthetic is required for the removal of the bone. The type of bone which lodges in these tissues is seldom demonstrated radiologically; exceptions to this

are to be seen in Figs. 9,10,11, pages 71,72,73, which demonstrate bones in this region.

For this examination good light is essential whether it be provided by a head mirror or head lamp leaving both hands free for manipulations. The tongue is depressed using any convenient type of tongue depressor, and the surface of each tonsil is in turn scrutinised for evidence of a fish bone (16% of fish bones removed are found in and around the tonsils). A small, bleeding crypt may mark the entrance of a bone or more frequently, a portion of bone is found protruding from a tonsillar crypt. The clefts between the anterior and posterior pillars and the to tonsils must be examined and if necessary, obliterated either by traction on the tonsil or the pillars. If the plica semilunaris is particularly large, it must be palpated. Thereafter, those portions of the posterior pharyngeal wall and base of tongue which are accessible to direct vision, are carefully searched for evidence of a bone. If the bone is found in these regions, it is merely grasped with any convenient pair of forceps and removed under direct vision. The hypopharynx, below the level of direct vision, is

Fig. 9

A flat fish bone in a three year old child extending from the base of the tongue to the hypopharyngeal aspect of the oesophagus. (Enlarged Copy)

Fig. 10

A chicken bone wedged across the valleculae between epiglottis and base of tongue. The horizontal bone just below this is the hyoid.

Fig. 11

A small fish bone in the same position as in Fig. 10. It is clearly demonstrated by virtue of the contrast-medium of air which surrounds it.

examined with the aid of a large laryngeal mirror. The successful use of this instrument requires practice, patience and perseverance, bearing in mind that it is unpleasant to the patient who is in some degree of pain. The tip of the protruded tongue is grasped between two layers of gauze or lint, using the thumb and index finger of the left hand. While maintaining gentle traction on the tongue, the laryngeal mirror, held in the right hand with the reflecting surface facing downward, is then carefully passed over the back of the tongue and held against the posterior part of the soft palate. This reflects the examining light down into the hypopharynx and a clear image of the hypopharynx can be seen in the mirror which should be warmed to body temperature over a spirit flame to prevent condensation of moisture on its surface. The base of the tongue, valleculae, aryepiglottic folds, pyriform fossae, larynx and posterior pharyngeal wall, are all searched in turn. The bone might be observed in the recess of a mucosal fold but an accumulation of mucus or blood-stained mucus raises suspicion. The pooling of saliva in the hypopharynx indicates reluctance or inability on the part of the patient, to swallow and is usually due to trauma of the upper oesophagus possibly with the foreign body still in situ. In patients with a brisk gag reflex, the

above examination will be facilitated by spraying the pharynx and hypopharynx with cocaine (5% or 10%) or any other efficient surface anaesthetic agent.

If a bone is discovered, the exact position must be noted. Removal by indirect vision, using curved forceps, requires particular skill. Removal under direct vision is simpler and not unduly disturbing to the patient, especially after the application of a surface anaesthetic. The patient is placed in the supine position with a pillow under the shoulders and the neck extended. Any type of laryngoscope such as commonly used by anaesthetists, is introduced over the tongue, taking special care not to damage the teeth or impact soft tissues on them. The instrument is guided directly to the site of the bone which has previously been noted on indirect examination. The bone is visualised and grasped with a Magill's or Luc's forceps or any other conveniently curved instrument, taking care not to include mucosa in the jaws of the instrument. The bone is disimpacted and removed. Such a successful manoeuvre is highly satisfactory to the patient who, in an uncomplicated case, has been spared admission to hospital and a general anaesthetic. They are invariably grateful patients who depart triumphantly with

the offending bone to show to anxious family or friends. They are however, instructed not to take anything by mouth until the effect of the local anaesthetic has subsided.

SPECIAL INVESTIGATIONS.

If, by the methods so far described, no bone has been demonstrated, the patient's neck is radiographed in the lateral position. The field covered extends from the base of the skull to the apex of the thorax. The technique employed is intended not to demonstrate the vertebrae but the soft tissues and any minor opacities. This lateral radiograph rarely shows the type of bone which lodges in the supraoesophageal tissues (Figs. 9,10,11, pages 71,72,73) but frequently shows the bone found in the oesophagus down to the level of the first or second thoracic vertebra. An additional radiograph taken during the act of swallowing may reveal a foreign body elevated into view but not normally visible. A calcified lymph node, calcified portions of thyroid and laryngeal cartilages and osteophytes arising from the bodies of the vertebrae, should not confuse the experienced observer. See Figs. 9 and 11, pages 71 and 73.

An antero-posterior radiograph is likely to demonstrate only extremely dense foreign bodies as in this position the oesophagus is superimposed on the opacity of the vertebrae.

The definite demonstration of a bone constitutes a positive diagnosis and gives valuable information regarding the position, size and shape of the bone.

In the absence of such a positive result, the radiograph may still provide additional information. Localised swelling of the oesophageal tissues, distorting the contour of the air-containing trachea, denotes either inflammatory or traumatic oedema but not necessarily the presence of a bone. See Figs. 12, 13 and 14(a), pages 78, 79, and 80.

A bubble of air within the lumen of the oesophagus is found just below a painful swelling of the oesophagus. The reason for the persistence of the bubble, is that no food is being swallowed to carry it down and eructation is prevented by the painful oedema. The explanation given by Shanks and Kerley (1950) in their "Textbook of X-Ray Diagnosis", is that the oesophageal walls cannot come into apposition on account of

Fig. 12

A meat bone after 96 hours. The patient complained of interscapular pain and signs of inflammation were present in the neck. Swelling, maximal around the bone, displaces the trachea anteriorly.
Note the osteophytes arising from the vertebral bodies.

Fig. 13.

Gross inflammatory distension of the retro-oesophageal and retro-pharyngeal tissues due to the retention of a meat bone for 72 hours. There was in addition, suppurative mediastinitis. No drainage was done. Complete recovery followed antibiotic therapy.

Fig. 14(a)

An entire vertebra of a sheep lodged at the level of the "crowded out" area. In this case, anterior displacement of the trachea is not due to inflammation but to the gross dimensions of the foreign body.

Compare Fig. 12, page 78.

Fig. 14(b)

The vertebra removed from the patient referred to in Fig. 14(a).

being held apart, presumably by a foreign body. This explanation is unlikely to be correct for the following reasons:

(a) If the bone were in this air-containing space, it should be demonstrable radiographically in at least a few cases by virtue of the contrast-medium of air.

(b) The oesophagus adapts itself completely to the shape of all foreign bodies and obliterates any air space except a hypothetical basket-shaped foreign body.

(c) Bones, when present, are not removed from the level of the air column but above it. See Figs. 15(a), 15(b), pages 83, 84.

Irregular plaques of air outside the oesophagus may be visible before emphysema is palpable and obviously indicates perforation. See Fig. 16, page 85.

Radiographs of that portion of the oesophagus below the level of the second thoracic vertebra, are most unlikely to demonstrate a bone through the mediastinal and cardiac opacities.

Fig. 15(a)

A column of air in the oesophagus at the level of the seventh cervical vertebra. The foreign body, a sharp fish bone, is embedded in the tissues between the base of the tongue and the epiglottis. This is a gross example of the bone being at a higher level than the column of air.

Fig. 15(b)

A flat fish bone at the level of the seventh cervical and first thoracic vertebrae. The air seen below this is not intra-oesophageal but is the typical appearance of the pulmonary apex in this projection.

Fig. 16

Air distributed irregularly throughout the tissues of the neck due to perforation of the oesophagus. Note foreign body still in situ.

BARIUM SWALLOW.

The knowledge of the radiological features of an oesophageal foreign body visualised by the aid of a barium swallow, does not seem to have advanced since 1918. The features described by Guthrie and Holland in that year are still quoted in modern textbooks. They are:

(a) Complete obstruction to the flow of barium.
(This type of case should never be subjected to such an examination. The diagnosis is obvious clinically and any endoscopist who has struggled through the white sludge which tends to block the suction tubes, learns his lesson once only.)

(b) Deviation or forking of the stream.
(It requires an exceedingly large foreign body, like the stone of a fruit, to present this appearance on a fluorescent screen.)

(c) Spasm or abnormal contraction of oesophageal wall usually at the point of impaction.

(d) Residue of barium, often like a streak, persisting after drinking water.

(The principal objection to features (c) and (d) is that such appearances are more often produced by lacerations than by the presence of the bone.)

In actual practice it was found that when endoscopy was performed on a radiological diagnosis based upon a barium swallow, the recovery of a bone was exceptional. See Fig. 17, page 88. Conversely, negative reports on barium swallow were, at times, followed by removal of a bone.

The use of cotton wool impregnated with barium is mentioned only to be condemned.

The experience of others appears to have been equally unfavourable. Diggle (1952) writes, "The radiologist must be conversant with the sites of natural delay which occurs during normal deglutition, otherwise great confusion may arise and even dogmatism."

Shanks and Kerley (1950) conclude their chapter on X-Ray diagnosis as follows, "The patient's history and symptoms must carry more weight than a negative radiological examination and the final responsibility must rest with the endoscopist and not the radiologist."

Fig. 17

An example of a radiological diagnosis of an intra-oesophageal foreign body opposite the sixth cervical vertebra based upon a barium swallow. No foreign body or laceration were found.

THE VALUE OF RADIOLOGY IN THE DIAGNOSIS OF SWALLOWED BONES.

Meat Bones.

Eighty-five percent of the meat bones removed, were demonstrated on "straight" radiographs. Half of the remaining cases were submitted to barium swallows without additional diagnostic success.

Chicken Bones.

Fifty-seven percent of the chicken bones removed were demonstrated on "straight" radiographs. The remaining cases were not submitted to barium swallows.

Fish Bones.

Twenty-nine percent of the fish bones removed were demonstrated on "straight" radiographs. Approximately one third of the remaining cases had barium swallows. These barium examinations produced a negative result in most, inconclusive findings in some and a positive diagnosis in one case.

"Straight" radiographs are therefore of greatest value in meat bones and of least value in fish bones, with chicken bones occupying an intermediate position.
See Fig. 18, page 91.

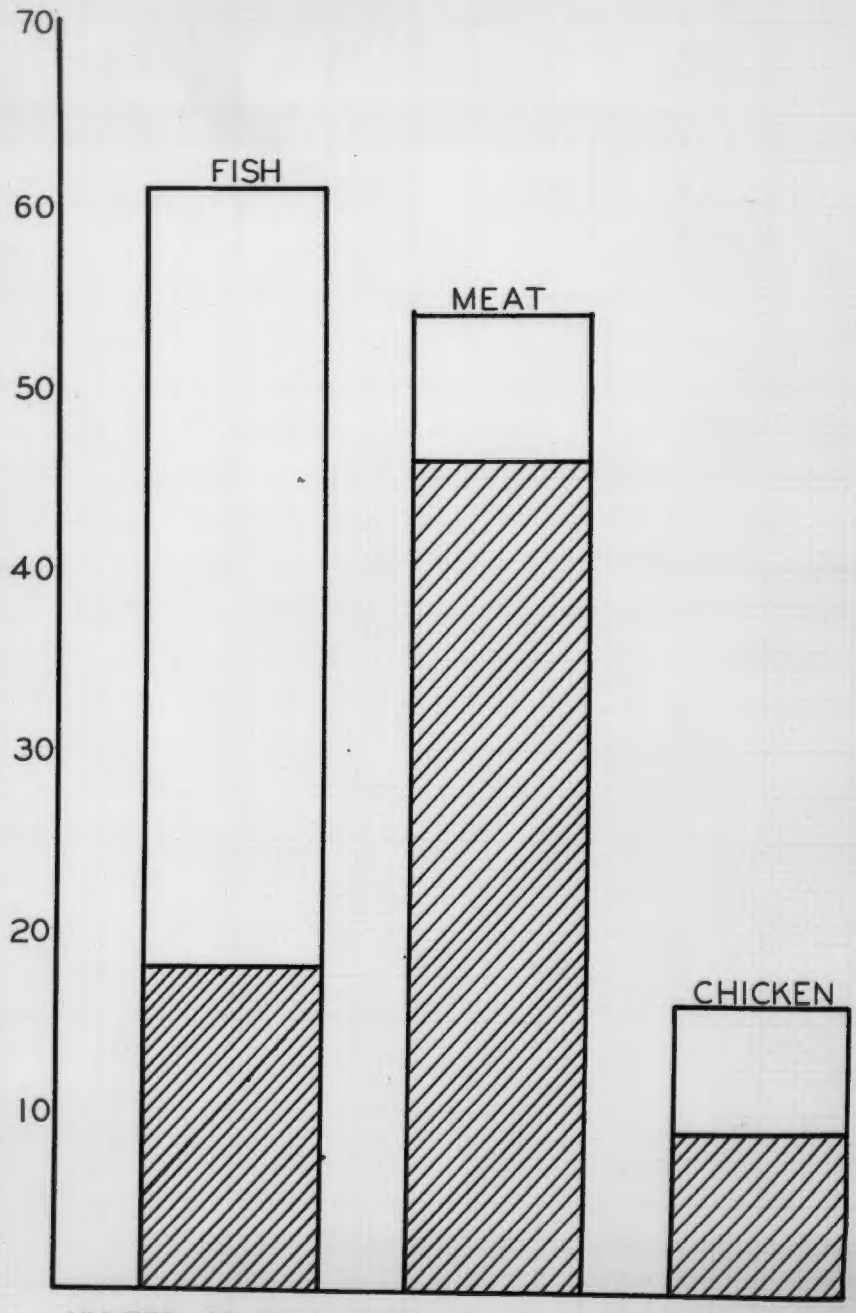
A barium swallow does not contribute to the diagnosis of a swallowed bone and in many instances, confuses the issue.

A positive radiological diagnosis is of the greatest value, especially when the bone is lodged in the oesophagus where, for practical purposes, it is beyond clinical examination. A negative radiological diagnosis is of no value.

Thus far, the following constitute a positive diagnosis which justifies immediate action :

1. The visualisation of a bone before it enters the oesophagus (in the mesopharynx or hypopharynx). The removal of these bones has been described. See Page 75.

2. The clinical evidence of complete oesophageal obstruction.



NUMBER OF EACH TYPE OF BONE REMOVED.
SHADED PORTION INDICATES NUMBER OF
POSITIVE RADIOLOGICAL DIAGNOSES.

Fig. 18

3. The demonstration of a bone on a "straight" radiograph.

This unfortunately leaves a large number of patients in whom the diagnosis of the presence of a bone, is presumptive. Such presumptive evidence may be weak, moderate or strong, depending upon evaluation of symptoms and signs. It has been stressed that that the symptomology of the presence of the bone is identical to that of the trauma caused by the bone no longer in situ. The most valuable differentiating factor is time. The symptoms of trauma improve while those of the foreign body do not. Unfortunately there is often the complication introduced by the taking of vinegar. In the absence of a positive diagnosis, oesophagoscopies performed within twelve hours of swallowing the bone, were not rewarded with many successes. Oesophagoscopies performed after twenty-four to forty-eight hours (the presumptive evidence had stood the test of time) recovered a much greater percentage of bones. Strong presumptive evidence includes the following cases:

1. Symptoms unchanged or worse after twenty-four hours.
2. The presence of complications (when first seen) e.g. perforation, spreading infection. The latter

is rare within twenty-four hours.

3. A combination of symptoms and signs each of which individually does not constitute strong presumptive evidence.

HOW LONG MAY OESOPHAGOSCOPY BE DELAYED?

All bones positively diagnosed must be removed as soon as possible or within hours of commencement of treatment of complications. Similarly, endoscopy should be performed in all cases with strong presumptive evidence of the presence of a bone. The remaining cases may safely and with advantage, be kept under observation for twenty-four or even forty-eight hours.

It is a little disturbing to note that two patients with a positive radiological diagnosis were left overnight for special reasons; in the morning their symptoms had improved and on repeating the X-Ray examination, the bones were found to have passed on. In addition to these, there were a few patients, similarly with positive radiological evidence of bones which, when endoscopy was performed after some hours delay, were found to have disappeared. These cases are however, exceptional

and endoscopy should follow a positive diagnosis. It is interesting to note that Woodburn (1950) of the Children's Hospital, Brisbane, similarly advises removal of foreign bodies - "there being only a small chance of the object passing onwards." Of thirty-eight radio-opaque objects (including a penny at fifteen months of age) which reached the stomach, all passed without incident. In contrast to this, Kugelmass (1951) suggests dislodging foreign bodies inhaled or swallowed by children, using aminophylline per rectum to relax the muscles and allow the foreign bodies to be coughed up or passed down.

COMPLICATIONS. OESOPHAGOSCOPY. MORTALITY.

These three are considered together as each is intimately concerned with the other.

INFECTION AND PERFORATION.

A minor degree of superficial infection is present in many cases in which the bone has been retained for forty-eight hours or more. The infection may remain within the limits of the submucosa or spread to the immediate perioesophageal tissues

or more distantly into the tissues of the neck or mediastinum. The causal bone need no longer be present and the spread of infection does not necessarily imply perforation of the oesophagus.

In this series, six very ill patients arrived at hospital with spreading infection. They had all been under medical care; the bones had been swallowed more than forty-eight hours previously and two had been the unfortunate victims of an oesophageal sound. The passage of an oesophageal sound, bougie or probang in the hope of dislodging the bone, is definitely to be condemned. This was not an uncommon practice forty years ago and carried a high mortality. Wright (1934) reported three cases of suppurative mediastinitis following perforation of the oesophagus by bones. In two of these a probang had been passed.

Two other similar cases in this series had not been subjected to instrumentation.

The fifth case had marked surgical emphysema and a pleural effusion. The treatment given before admission to hospital had not been mentioned.

The sixth case had a well-formed abscess pointing into the lumen of the oesophagus. This was drained oesoscopically and a fish bone recovered from the cavity. Thereafter the patient improved rapidly.

The first five cases had varying degrees of cellulitis of the neck and mediastinitis but no suppuration. They all recovered on heroic doses of antibiotics, parenteral feeding and endoscopic removal of the offending bones. In two patients no bones were ever found.

To complete the picture of perforations, two more cases were perforated in the course of endoscopic recovery of the bones. They were similarly treated; one recovered rapidly and the other, a sixty-eight year old female, had a prolonged convalescence during which pleural aspiration was performed several times.

Severe laceration of the oesophagus was observed in many of the cases at the time of removal of a bone. Depending upon the severity, these were either given nil per mouth or sterile fluids only for a day or two and on antibiotic therapy, all made uneventful recovery.

No perforations were ever sutured, no bones were removed by open operation and no open drainage was performed

for suppuration.

In contrast to these not unsatisfactory results, Phillips (1938) quotes Broyler, ".....perforation of the oesophagus results in a mediastinal infection which is fatal." Quoted by the same author are:

Franz Torek, "If in consequence of such injury, the mediastinum or pleura is opened, death from infection is almost certain to occur."

Graham, Singer and Ballow, "The occurrence of a perforation of the oesophagus is, in the vast majority of cases, associated with fatal consequences."

Then followed an era of surgical attack on these perforations. Suture was combined withdrainage, so preventing suppuration in many cases. Open operation for the removal of oesophageal foreign bodies had been practised even earlier. Killian, quoted by Flett (1945) reported on 380 cases of oesophageal foreign bodies occurring between 1900 and 1922. Open operations were performed on 169 cases but 70 of these died.

To what may one attribute this remarkable improvement

in the prognosis of oesophageal perforation and non-suppurative mediastinitis or cellulitis of the neck? The answer is obvious - antibiotics and more antibiotics, combined with skilful endoscopy. This view is shared by Korkis (1952) who agrees that in the chemotherapeutic and antibiotic age, perforation of the oesophagus by no means always leads to abscess formation. Today it is unusual to find suppurative mediastinitis following penetration by a foreign body. It is strange that Asherson (1951) writing on this problem, does not mention antibiotics.

It is suggested that surgery be reserved for suppurative infections. As a preliminary to such an operation, an oesophagoscope should still be passed and, if the abscess is found pointing into the lumen of the oesophagus, it should be drained via this route. Only the submucosal and limited pericesophageal abscess is likely to localise sufficiently to point in the lumen. Suppurative mediastinitis disseminates widely on account of constant motion of its components. The particular course which the infection takes, depends on the magnitude of the penetration or perforation, the virulence of the organisms and early commencement of appropriate antibiotic therapy. When suppuration has occurred, drainage must be effected either

via the oesophagus or externally. No amount of antibiotic treatment per se can be expected to cure the condition. Lilienthal (1936) put it very aptly, "Doctors are afraid to have the mediastinum operated upon. The patient will die if he is not operated upon, and he cannot do worse if he is." Therefore the diagnosis of suppurative as opposed to non-suppurative infection is of vital importance. All cases start as perioesophageal cellulitis, pus forming later. The early detection of this pus is very difficult. In the cervical oesophagus which is accessible to clinical examination, the usual criteria apply. In the mediastinum it constitutes a diagnostic problem of the highest order. If suppuration is present before the institution of treatment, the patient exhibits the general signs of toxaemia, tachycardia, swinging temperature, leucocytosis and rapid deterioration. In the presence of antibiotic therapy, these signs are likely to be minimal. Radiographs of the neck and chest may show a collection of fluid, displacement of the trachea, a wide mediastinal shadow or displacement of the oesophagus as evidenced by the swallowing of sterile iodised oil. Culver and Clark (1947) and Adams (1946) advocate the use of barium but in the presence of perforation this must be unwise. A tender inflammatory swelling may appear

in the lower part of one or both sides of the neck. As a general rule, the patient should improve daily and such improvement must be maintained after cessation of treatment.

Cervical mediastinotomy should be sufficient provided the abscess does not extend below the fourth thoracic vertebra. If it is lower, then posterior mediastinotomy should be added.

OTHER COMPLICATIONS FOLLOWING INFECTION AND PERFORATION.

Hadfield (1950) has recorded the precipitation of a dissecting aortic aneurysm by a swallowed bone.

Barrie and Townrow (1946) in revieuing the literature up to 1940 discovered eighty horrifying cases of perforation of the aorta by foreign bodies in the oesophagus. More recently Stein, Paternack and Meyers (1950) have reported a case of aortic-oesophageal fistula with fatal haemorrhage secondary to swallowing a fish bone. Davy and Bulteau (1950) describe a similar case, also due to a fish bone, except that haemorrhage occurred twenty days later due to rupture of a

false aneurysm.

Retropharyngeal cellulitis and abscess occur due to penetration of the pharyngeal wall. Empyema, penetration of the trachea-bronchial tree with resultant lung abscess and gangrene have all been described. Death due to pneumopericardium was recorded by Arens and Stewart (1934).

The complication of healing viz. stricture formation at the site of laceration or perforation, has not occurred in this series.

Of the two hundred and four bones which negotiated the oesophageal pathway successfully, there does not appear to have been any abdominal or ano-rectal misadventure.

OESOPHAGOSCOPY.

The technique of oesophagoscopy does not fall within the scope of this analysis. Suffice it is to say that an endoscope in the hands of the inexperienced may be as lethal a weapon as a firearm. Like all surgical prodedures, a particular oesophagoscopy for the removal of a foreign body may be easy and encouraging but others will tax to the limit the ability

of the most highly skilled and experienced endoscopist. A coin is possibly the least traumatic of all swallowed foreign bodies and its removal is the easiest. Yet Flett (1945) reports an unfortunate occurrence when a piece of mucosa was unwittingly picked up causing a small tear. An abscess was followed by mediastinitis and death.

MORTALITY.

It might be argued that one has gone to too great a length to prove the presence of a swallowed bone before deciding upon oesophagoscopy. Why not pass an endoscope and make certain? Boyd (1951) showed a 2% mortality. Diggle (1932) recorded a 1.4% mortality in the removal of sixty-seven foreign bodies from the oesophagus. Chevalier Jackson, Professor of Bronchoscopy and Oesophagoscopy at the University of Pennsylvania, had a mortality of 2%.

In the present series of one hundred and thirty-one bones removed, eighty-nine under general anaesthesia, two patients succumbed. These deaths were not due to the complication

of the bones. They both died of primary cardiac arrest. Response to resuscitative measures was short lived. They represent the two extremes of life; one was an infant aged ten months, with the jawbone of a fish containing a tooth, wedged in the upper oesophagus. Cardiac arrest occurred just as the foreign body was visualised. No attempt at withdrawal was made. The other was a sixty-five year old, obese female. No bone had yet been identified when she died. Both anaesthetics were given by expert anaesthetists.

The concept of reflex cardiac death while manipulating a hollow viscus under anaesthesia, is no longer as popular as it was a few years ago. This explanation of sudden unexpected death was indeed abused for years after its introduction by Brouardel of Paris during the last century. Adelson (1953) suggests that it is a very real entity. Barrie and Townrow (1946) mention an unusual case of cardiac arrest occurring during oesophagoscopy without general or local anaesthesia. Electrocardiographic tracings during endotracheal intubation under general anaesthesia have shown the effect of this manoeuvre on the action of the heart.

Whatever the mechanism of death in these two

patients, they reflect an incidence twenty-two times greater than the overall incidence of "anaesthetic deaths".

It is evident that the swallowing of bones may have dire results. The removal of these bones is not without risk. Let us attempt, by more accurate diagnosis and appropriate treatment, to ensure a better management of those who in the future, will be the inevitable victims of swallowed bones.

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