Section 3  Radiological aspects

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The role of the radiologist is limited, but he can contribute much useful information. In the past he has often been required to confirm or deny symptoms which the clinician thinks might be due to reflux. If the radiologist saw reflux or hernia the clinician was happy with his diagnosis; if the radiologist did not, the clinician often either discounted the symptoms as unimportant or looked for another cause. This is not the way to treat your radiologist! He cannot, by definition, see intermittent reflux which may nevertheless produce severe symptoms and even inflammatory changes in the mucosa. He can tell you whether there is an oesophageal, gastric, or duodenal ulcer or a carcinoma in these areas, or about the presence and nature of an obstruction, and he may see radioopaque gallstones or calcification in the pancreas; but unless he takes a history himself he cannot tell you whether the symptoms are due to gastrooesophageal reflux (see section 5 and 6).

Radiology can determine the capacity to herniate and whether herniation is intermittent or continuous. It can imply that surgery is out of the question, according to some surgeons, because there is no capacity to herniate and so no hernia to repair. If surgery is to be contemplated, radiology can measure the amount of stomach in the chest in certain positions, and indicate the probability of torsion and volvulus, a complication which may be precipitated by the weight and volume of barium that may be trapped in the thoracic stomach. The degree to which the stomach may be fixed within the chest or at the hiatus margin can be assessed. The size of the hiatus can be measured by the width of the barium column; and the severity of the mechanical defect which allows intraabdominal pressure to exert its full force into the thoracic locusus can be gauged. Consistent free flow across the hiatus and up the oesophagus cannot be stopped by medical methods.

What the radiologist sees depends very much upon what he does. Technique is of paramount importance but not everything can be looked for with maximum efficiency at the same examination. It is especially important for the clinician to indicate to the radiologist what his problem is; what he particularly wants to know and why; are other conditions to be excluded; is surgical repair contemplated; is there any suggestion of obstruction; is the problem one of regurgitation or of true vomiting.

Various postures have been advocated to demonstrate herniation and reflux. The erect position only helps in deciding whether the stomach can wholly reduce. If part remains in the chest it may still not be incarcerated, but it suggests that a large part of the stomach may be in the chest when the subject lies down. The prone horizontal or head-down position brings the oesophagogastric junction away from the filled fundus so reflux of radioopaque material may be less marked, while the prone-over-a-bolster position exerts such stress on the hiatus structures that as well as demonstrating the capacity to herniate in everyday life herniation may be provoked when it is irrelevant.

The position of choice is the 'antigravity' supine, in which the patient is tilted about 10° head down (Edwards, 1969). Slight elevation of the right side projects the oesophagus clear of the vertebral column and the back of the heart and gives a clear view of the hiatus region. Fluoroscopy is the key to the evaluation of what is essentially a dynamic process and single radiographic views may be misleading.

The gastrooesophageal sphincter normally lies across the diaphragmatic hiatus and the prime radiological criterion for establishing the presence of herniation is the identification of the position of the sphincter in relation to the diaphragm. The head-down position ensures that the oesophagus is dilated, reveals the different contractility of the sphincter, and distends the supradiaphragmatic locusus (Edwards, 1969) which often has a characteristic indentation on its left lateral margin (Berridge, 1967). The normal peristaltic wave stops at the end of the sphincter segment but this observation is of limited use in defining the sphincter. One source of confusion is the phrenic ampulla which is often recorded on the x-ray film and may be mistaken for a herniated stomach. Arguments continue about its genesis (Wolf, 1967) but in practice it occurs at the distal end of an oesophagus with a normally situated sphincter and a peristaltic wave inadequate to propel all the barium into the abdomen against the gradient of pressure between abdomen and thorax. A blob of barium is left in the chest which mimics a small hernia, and to compound the confusion, as the oesophagus relaxes after the
peristaltic wave has passed, the barium runs back, simulating reflux. Herniated stomach should always have a definable sphincter segment proximal to it.

The demonstration of continuous herniation presents no problem, but to demonstrate the capacity to herniate or reflux may require examining the patient while he is rolling from left to right or straight leg raising, or touching his toes, or squatting from the standing position. Reflux may occur in only one of these positions and most commonly occurs in that position in which the patient most commonly has symptoms. Manual compression, the Valsalva and Müller manoeuvres, are difficult to perform and give rise to physical and mental distortions in examiner and examinee. Although in our experience radiological evidence of reflux in the absence of the capacity to herniate is rare in adults such reflux may sometimes be seen following gastrectomy, hiatal hernia repair, and cardio-myotomy (see section 1).

It is important to differentiate hiatal flow (Edwards, 1969), that is, the flow of barium and gastric contents from abdominal to thoracic stomach, from gastrooesophageal reflux. Hiatal flow is variable and is dependent upon the size of the hiatus, the size of the hernia, and the position and activity of the patient. If the hiatus is small, the physical mass of the stomach in the hiatus, the pressure difference across the diaphragm, and the contraction of the diaphragm on inspiration may close off the stomach, preventing flow into the thoracic part of the stomach so that the sphincter mechanism is not challenged (Edwards, 1961) (see section 1, Fig. 1b). Gastrooesophageal reflux is influenced by the freedom of hiatal flow and the size of the stomach loculus. If hiatal flow is minimal, reflux from the stomach may be small in the circumstances of the examination but nevertheless the patient may have severe symptoms. If the supradiaphragmatic loculus is large (section 1, fig. 1c) reflux is not so

Fig. 5 (a) Barium swallow in the erect posture suggests a stricture but of what length? (b) The 'antigravity' posture delineates both the proximal and distal oesophagus and the length of the stricture.
dependent upon hiatal flow. Gastrooesophageal reflux may be intermittent and failure to show reflux in the presence of a capacity to herniate does not preclude it. Although swallowing relaxes the sphincter it very rarely induces reflux of barium when no herniation is visible, but the relaxation of the sphincter above a hernia sometimes allows barium to reflux (Edwards, 1961).

Oesophagitis and stricture formation can be detected and quantitated by radiology because the inflammatory process has decreased the distensibility of the wall of the oesophagus (see section 2). Oesophagitis and benign stricture almost never cause sufficient narrowing by oedema and muscle 'spasm' to stop the flow of liquid barium (see section 1), which only happens by the muscular closure of achalasia or the total closure of cancer. Oesophagitis occurs mainly at and just proximal to the junction of squamous and columnar epithelium but ulceration of squamous epithelium is usually very shallow (see section 2) and radiologically visible ulcers are usually in the columnar epithelium (see section 2). Loss of distensibility of the wall can only be demonstrated by full distension proximal and distal to the inflamed segment. This is best detected at fluoroscopy when the changing diameter of the normal contrasts with the persisting failure of the inflamed segment to expand. Adequate distension can only be obtained while the subject is drinking steadily in the 10° head-down position, preferably swallowing frequently enough to inhibit the peristaltic wave (Edwards, 1969). By this means the length, maximum bore, nature, and toughness of a stricture and its proximal and distal 'shoulders' can most clearly be seen (figs. 5a and 6). Many strictures contract down to obliterate the lumen as the peristaltic wave runs into them, although they cannot open very far (see section 2). Inability to obliterate the lumen, or the presence of deep shoulders proximal and distal to the stricthed segment indicate a mature fibromuscular stricture that is unlikely to respond to dilatation and will not melt away if reflux is stopped. If the patient claims that solids produce a sensation as they pass down the oesophagus a bolus of a mixture of new crusty bread and a little barium, swallowed whole, will sometimes outline a segment of slightly diminished distensibility which may indicate enough inflammatory change to be the early stages of stricture formation.

Ring strictures, or Schatzki rings (MacMahon et al, 1958; Schatzki, 1963; Wolf, 1967; Edwards, 1969), are much more readily detected by radiology.

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**Fig. 6** (a) The erect swallow provides less information about this lower oesophageal stricture and ulcer than (b), the 'antigravity' technique with better distension.
Section 4  Pharmacology and therapeutics

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None of the various methods available for study of oesophageal pharmacology is wholly satisfactory. Radiological screening is of limited value for reasons discussed by my colleagues. Gastrooesophageal reflux can be detected by the measurement of oesophageal pH with an indwelling electrode (Tuttle, 1958; Patrck, 1970), and records of reflux during an extended period, eg, at night (see section 5), and of the effects of drugs or hormones upon it can be made (Stanciu, 1972). This is a valuable method which provides objective measurements of periods during which oesophageal mucosa is exposed to acid (see section 1).

Most research on oesophageal function and pharmacology has been performed by measuring intraluminal pressures, usually with a multilumen assembly of tubes. The test is easy to perform, but the analysis and interpretation of the records is less easy. The type of pressure sensor at the distal end of the tube, whether balloon or open-ended tip, can affect the amplitude and shape of recorded pressure waves. Fortunately, the introduction of the constantly perfused open-ended tip (Winans and Harris, 1967; Pope, 1967), has not only advanced knowledge of sphincteric function, but has led to greater uniformity in methods of recording. Although intraluminal manometry is an important research tool, there are certain uncomfortable facts that have to be faced. For example, Why is it that pressures recorded from the same cardiac sphincter, by perfused tubes, successively pulled through it at short intervals of time, can vary so widely? This is not to
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