Thorax (1976), **31**, 284.

Observations on oesophageal length

G. J. KALLOOR, A. H. DESHPANDE, and J. LEIGH COLLIS

The Queen Elizabeth Hospital, Birmingham

Kalloor, G. J., Deshpande, A. H., and Leigh Collis, J. (1976). *Thorax*, **31**, 284–288. **Observations on oesophageal length.** The subject of oesophageal length is discussed. The great variations in the length of the oesophagus in individual patients is noted, and the practical use of its recognition in oesophageal surgery is stressed. An appraisal of the various methods available for this measurement is made; this includes the use of external chest measurement, endoscopic measurement, and the measurement of the level of the electrical mucosal potential change.

Correlative studies of these various methods are made, and these show a very high degree of significance. These studies involved simultaneous measurement of external and internal oesophageal length in 26 patients without a hiatal hernia or gastro-oesophageal reflux symptoms, 42 patients with sliding type hiatal hernia, and 17 patients with a peptic stricture in association with hiatal hernia.

The method of measuring oesophageal length by the use of the external chest measurement, that is, the distance between the lower incisor teeth and the xiphisternum, measured with the neck fully extended and the patient lying supine, is described in detail, its practical application in oesophageal surgery is illustrated, and its validity tested by internal measurements. The findings of this study demonstrate that the external chest measurement provides a means of assessing the true static length of the oesophagus, corrected for the size of the individual.

Cunningham (1902) observed that the length of the oesophagus varies in different individuals from 20 to 35 cm, the distance from the upper incisors to the beginning of the oesophagus averages 15 cm, and the breadth varies between 13 mm in the empty contracted state to 30 mm in the fully distended condition. At endoscopy the usual length is 40 cm, measured from the incisor teeth to the point where the mucosal change occurs. Acceptance of the above figures is likely to lead to error if account is not taken of the fact that the length of the oesophagus varies from one person to another. This difficulty is often experienced when trying to reduce sliding type hiatal herniae of similar size; reduction is easy in one and impossible in the other. The length of the oesophagus may be a factor determining whether a hiatal hernia is reducible or not. There is only one real cause of shortening of the oesophagus, that is, shortening of its muscle length. Longitudinal muscle dysfunction can result in permanent shortening of the oesophagus with misplacement of the cardia into the chest. Irreducibility of the hiatal hernia is a characteristic feature in cases of peptic stricture with oesophagitis and shortening of the oesophagus. Shortening of the oesophagus is also seen in collagen disorders such as systemic sclerosis and after irradiation for oesophageal carcinoma. Lengthening of the oesophagus is seen classically in advanced cases of achalasia with paralysis and dilatation.

Observations have shown great variations in the length of the oesophagus in adults, between 46 cm and 33 cm as measured between the incisor teeth and the oesophagogastric mucosal junction.

METHODS AVAILABLE FOR MEASURING OESOPHAGEAL LENGTH

(1) Use of the external chest measurement as an index of oesophageal length (Figure).
(2) Endoscopic measurement of length, based on identification of the level of the mucosal change (cardia).
(3) Measurement based on the level of change of gastro-oesophageal electrical mucosal potential.
(4) Radiological measurement made from standard landmarks.

MATERIAL AND METHODS

Measurements were made in three groups of patients admitted to hospital.

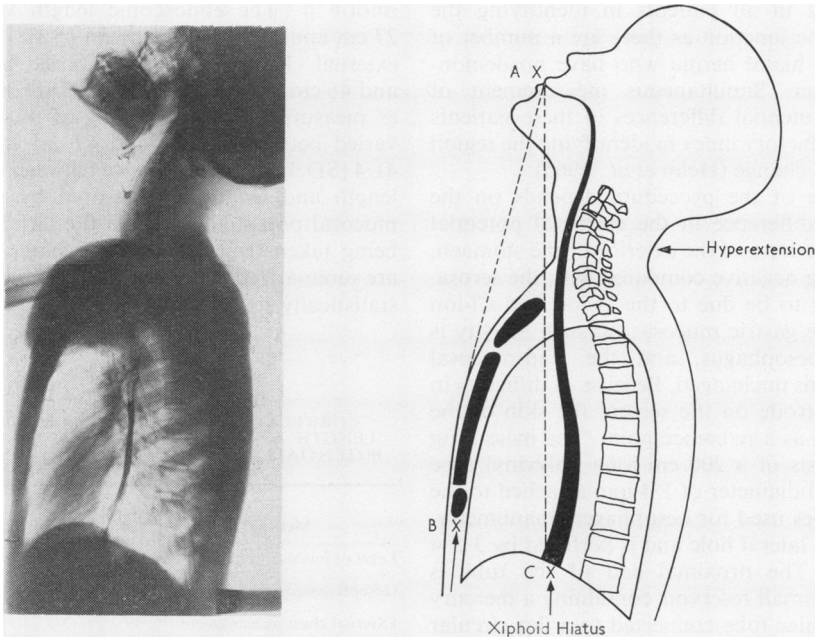

FIGURE. *Lateral radiograph with a barium swallow taken in the simulated oesophagoscopy position and its diagrammatic representation showing that the distance AB=AC. AB=distance between lower incisor teeth and lower margin of xiphoid process. AC=distance between lower incisor teeth and the diaphragmatic pinchcock.*

GROUP I Twenty-six patients had no hiatal hernia or reflux symptoms. Ten patients had a lung neoplasm, 10 patients were suffering from dyspeptic symptoms for which no organic cause could be found, and in the remaining six patients, two had a history of haematemesis without an obvious cause, one had mitral stenosis, one had a double aortic arch, one had an empyema, and one had a pulmonary hamartoma. Their ages ranged between 35 and 72 years (mean $54 \pm 8{\cdot}98$). The level of the cardia (the gastro-oesophageal mucosal junction) from the lower incisor teeth was taken as the internal oesophageal length.

The external chest measurement is the distance between the lower incisor teeth and the xiphisternum (d'Abreu, Collis, and Clarke, 1971). This was measured with the patient lying supine, the head and neck fully extended as for a rigid oesophagoscopy. A 50 cm Irwin Moore oesophagoscope was then placed between these two landmarks, and the distance was read. If the lower incisor teeth were absent, the measurement was taken from the upper limit of the lower lip. The point of the xiphisternum was felt with the fingers, and the most definite and prominent lower part was taken for the measurement.

GROUP II Forty-two patients had reflux symptoms. All these patients had a sliding type hiatal hernia with gastro-oesophageal reflux. One patient with reflux but without a hernia was excluded. Their ages ranged from 26 to 71 years (mean $54{\cdot}2 \pm 10{\cdot}8$). The measurements were made at endoscopy and at oesophageal manometric studies, with simultaneous determination of the level of transmucosal electrical potential change.

GROUP III Seventeen patients had dysphagia and were found to have a peptic stricture secondary to a hiatal hernia. Their ages ranged between 36 and 77 years (mean $58{\cdot}7 \pm 17{\cdot}3$). Oesophageal manometric studies, with determination of the level of the mucosal electrical potential change, were undertaken after dilatation of the stricture at oesophagoscopy.

Oesophagoscopy was performed using an Irwin Moore oesophagoscope under a general anaesthetic or using an Olympus Model EF fibreoptic flexible oesophagoscope under intravenous diazepam.

DETERMINATION OF LEVEL OF MUCOSAL ELECTRICAL POTENTIAL CHANGE

The intraluminal pressure changes in the oesophagus

are not helpful in all patients in identifying the oesophagogastric junction as there are a number of patients with a hiatal hernia who have no demonstrable sphincter. Simultaneous measurement of transmucosal potential differences in these patients provides a satisfactory index in identifying the region of the epithelial change (Helm *et al.*, 1965).

The principle of the procedure depends on the existence of a difference in the electrical potential between the interior and the exterior of the stomach, the lumen being negative compared with the serosa. This is thought to be due to the H-ion and Cl-ion secretion by the gastric mucosa; no such activity is seen in the oesophagus, and the transmucosal potential remains unchanged. Because of difficulty in placing an electrode on the serosa, the skin of the forearm is used as a reference point. The measuring electrode consists of a 200 cm long polyvinyl tube with an internal diameter of 1·4 mm attached to the two similar tubes used for oesophageal manometry. This tube has a lateral hole and is perfused by 3·5 M KCl solution. The proximal end of the tube is connected to a small reservoir containing a mercury half cell. A similar tube connected to a flat circular disc of 2·5 cm diameter and perfused with 3·5 M solution of KCl is the reference electrode; the proximal end of this tube is also connected to a mercury half cell containing KCl to act as a salt bridge. The two half cells are connected to a voltmeter, the output from which is recorded along with the pressure measurements.

RESULTS

GROUP I The external measurement varied between 45 cm and 34 cm with a mean of 39·2 (SD $\pm$3·1). The internal length varied between 45 cm and 33 cm with a mean of 39·2 (SD $\pm$3·3). In eight patients both measurements were identical, in 10 patients the difference varied between 0·5 cm and 1 cm, and in the remaining eight patients the difference was between 2 and 3 cm. Table I summarizes the results. The internal length was measured at endoscopy in 18 patients, and in the remaining eight patients this was determined by the level of the change of mucosal potential.

TABLE I

CORRELATION BETWEEN EXTERNAL CHEST MEASUREMENT AND INTERNAL LENGTH OF OESOPHAGUS IN GROUP I (26 PATIENTS)

Method	Mean (cm)	SD	Significance of Correlation
External chest measurement	39·2	3·1	r = 0·9041
Internal length of oesophagus	39·2	3·3	P = < 0·001

GROUP II The endoscopic length varied between 27 cm and 45 cm with a mean of 37·1 (SD 3·1). The external chest measurement varied between 33 cm and 46 cm with a mean of 39·7 (SD 3·3). The length as measured by the changing of mucosal potential varied between 36 cm and 49 cm with a mean of 41·4 (SD 3·1). The difference between the endoscopic length and length as measured by the change of mucosal potential is due to the latter measurement being taken from the anterior nares. These results are summarized in Table II, and their correlation was statistically significant.

TABLE II

CORRELATION OF OESOPHAGOSCOPIC LENGTH, LENGTH AS MEASURED BY CHANGE OF MUCOSAL POTENTIAL, AND EXTERNAL CHEST MEASUREMENT IN GROUP II (42 PATIENTS)

Method	Mean (cm)	SD	Significance of Correlation
Level of mucosal potential	41·1	3·1	r = 0·7885
			P = < 0·001
Oesophagoscopic length	37·1	3·1	
			r = 0·4210
External chest measurement	39·7	3·3	P = < 0·01

GROUP III The endoscopic length varied between 30·5 cm and 39 cm with a mean of 35·3 (SD 2·5). The external chest measurement in this group varied between 36 cm and 42 cm with a mean of 39·4 (SD 2·5). The length as determined by change of mucosal potential varied between 34 cm and 47 cm with a mean of 40·6 (SD 3·5). These results are summarized in Table III.

TABLE III

CORRELATION OF OESOPHAGOSCOPIC LENGTH, LENGTH AS MEASURED BY CHANGE OF MUCOSAL POTENTIAL, AND EXTERNAL CHEST MEASUREMENT IN GROUP III (17 PATIENTS)

Method	Mean (cm)	SD	Significance of Correlation
Level of mucosal potential change	40·6	3·5	r = 0·7460
			P = < 0·001
Oesophagoscopic length	35·3	2·5	
			r = 0·8195
External chest measurement	39·1	2·5	P = < 0·001

DISCUSSION

Simultaneous measurements of external chest measurement and internal length were made in the first group of 26 patients admitted to hospital without hiatal hernia or reflux symptoms. In 18 of these

patients the external length was measured at endoscopy, and in the remaining eight this was determined by the level of mucosal potential difference. Table I shows the results of correlative studies between the external chest measurement and the internal length.

The correlation between the two measurements is highly significant, and it is concluded that this is a reliable method of indirectly measuring oesophageal length.

In sliding type hiatal herniae of the reducible or irreducible type, the distance in centimetres of the level of the cardia from the lower incisor teeth deducted from the external chest measurement gives the length of the herniated stomach. In cases of oesophageal carcinoma the level of the cardia is difficult to identify due to the obstruction. In this situation the external chest measurement gives the oesophageal length with accuracy in the absence of a hiatal hernia. In the planning of oesophageal resection, a lesion at 33 cm from the lower incisor teeth with an external chest measurement of 35 cm confirms the lesion to be in the lower third and therefore indicates a left-sided approach; a lesion at the same level with an external chest measurement of 45 cm would indicate a right-sided approach (laparotomy followed by right thoracotomy).

The use of external chest measurement is suitable except in patients with severe skeletal abnormalities of the chest, such as kyphoscoliosis, and in cases of inability to extend the neck due to cervical arthritis.

The present study has checked the validity of the external chest measurement beyond any doubt. Between May 1947 and December 1974, 3092 oesophagoscopies using the Irwin Moore oesophagoscope were performed at the Queen Elizabeth Hospital. Between 1971 and 1974, 234 flexible oesophagoscopies were performed, and the validity of the external chest measurement was checked on every occasion.

ENDOSCOPIC MEASUREMENT OF OESOPHAGEAL LENGTH

Identification of the cardia is made on visual appearances at endoscopy; however, difficulty may be experienced in the presence of oesophagitis. Histological examination of serial mucosal biopsies will settle this point. One of the advantages of the flexible fibreoptic oesophagoscope is its use in establishing the relationship between the mucosal junction and the diaphragmatic hiatus; this junction appears to be 2–5 cm proximal to the hiatus in cases of sliding type hiatal hernia. The mean length of herniation in group II was 2·6 cm and that in group III was 3·8 cm. This figure is obtained by deducting the endoscopic length from the external chest measurement. Normally, as shown, the internal oesophageal length and external chest measurement are the same. The group with sliding type hiatal herniae have shorter herniation (2·6 cm) compared with the peptic stricture group (3·8 cm). It was clear from the radiological findings that the group III herniae were irreducible. In group II the accurate measurement of the length of herniation did not help in deciding whether the hernia is reducible or irreducible.

RADIOLOGICAL METHODS OF MEASURING LENGTH

Barium swallow studies provide information on the functions of peristalsis and clearance of swallowed contrast. Identification of the junction of mucosal change is not always easy, due to poor filling of the lower oesophageal segment, often due to poor pinchcock action of the diaphragmatic crus. The presence of soft tissue shadows in obese patients and the respiratory movements make interpretation difficult.

However, a study from this unit of 27 patients (Habibulla, 1972) with a hiatal hernia with misplacement of the cardia showed significant correlation between radiology and the methods mentioned. The radiological mean was one and a quarter times greater than the manometric mean in measuring the length of herniation above the diaphragm. This difference was explained by Habibulla (1972) as due to the magnification factor in radiography.

CONCLUSION

Our findings indicate that the correlation between external chest measurement, oesophagoscopic identification of the level of mucosal change, and the level of mucosal potential change is significant in the groups of patients studied. External chest measurement provides a means of assessing the true static length of the oesophagus corrected for the size of the individual. These measurements provide an accurate estimate of the length of the oesophagus. This information has been found to be extremely useful in the surgical management of patients with oesophageal neoplasms and hiatal herniae.

We thank Miss Pat Cole for statistical help and analysis, Mr. T. F. Dee and Dr. J. M. Strakova for tables and illustrations, Dr. E. H. Mucklow and Mr. P. J. Bagshaw for the *x*-rays, and Miss J. Hoppitt for secretarial help.

REFERENCES

Cunningham, D. J. (1902). *Text-book of Anatomy*. Y. J. Pentland, Edinburgh and London.

d'Abreu, A. L., Collis, J. L., and Clarke, D. B. (1971). *A Practice of Thoracic Surgery*, 3rd edition. Edward Arnold, London.

Habibulla, K. S. (1972). The diaphragm as an anti-reflux barrier. *Thorax*, **27**, 692.

Helm, W. J., Schlegel, J. F., Code, F. C., and Summerskill, W. H. J. (1965). Identification of the gastro-esophageal mucosal junction by transmucosal potential in healthy subjects, and patients with hiatal hernia. *Gastroenterology*, **48**, 25.

Requests for reprints to: G. J. Kalloor, FRCS, Queen Elizabeth Hospital, Edgbaston, Birmingham B15 2TH.