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THE GASTRO-OESOPHAGEAL JUNCTION IN INFANCY

A COMBINED CINERADIOGRAPHIC AND MANOMETRIC STUDY

BY

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We have previously described the results of a combined cineradiographic and manometric study of the gastro-oesophageal junction in adults (Botha, Astley, and Carré, 1957). We now record results of a similar investigation on a small group of infants under 12 months of age, some of whom had a minor degree of partial thoracic stomach (" hiatus hernia " or " short oesophagus ").

METHOD OF STUDY

Intragastric and intra-oesophageal pressures were recorded using water-filled " polythene " tubes of 2.5 mm. external diameter connected to an electromanometer of the capacitance type (N.E.P. Ltd.) and a two-channel direct writing pen recorder (Sanborn " twin-viso cardiette "). The recording end of each tube had a side hole about 1 cm. from the tip, the latter being closed off. The position of the recording hole was indicated by a radio-opaque marker of known dimensions.

Cineradiography with image intensification and intermittent radiation was used as described for cine-angiocardiography (Astley, 1955 ; Astley and Oldham, 1956). Examinations were carried out at 16 frames per second. The precise instant of each picture was indicated below the pressure tracing on the second channel of the pen recorder.

The procedure used was, with few modifications, identical to that employed in the study of adults (Botha *et al.*, 1957). No local nasopharyngeal anaesthesia was used because of the danger of subsequent inhalation and also because it would have been impossible to prevent these small infants swallowing the local anaesthetic agent. To obtain recordings free from extraneous artefacts caused by crying and breath holding, all infants studied were given chloral hydrate. The aim was to induce no more than a somnolent state sufficient only to permit the withdrawal of the recording end of the " polythene " tube across the gastro-oesophageal junction under conditions of relaxation and quiet, regular breathing.

The recording tube was passed through the nose into the stomach and the infant rotated slightly into the left posterior oblique position. The tube was next attached to the manometer and filled with water. After confirming the position of the marker within the stomach and with the infant lying quietly asleep, the tube was withdrawn at a uniform rate until the marker lay within the oesophagus. During the period of withdrawal simultaneous pressure and cineradiographic recordings were taken. The procedure was repeated on several occasions, always first allowing time for the infant to fall off to sleep again. The recording tube was flushed through before each recording. At the conclusion, barium was given to demonstrate the situation and competency of the gastro-oesophageal junction.

METHOD OF ANALYSING AND RECORDING RESULTS

The indication on the pressure recording of the precise moment of each cine film exposure enabled salient points on the pressure curves to be accurately related to particular cine frames (Fig. 1 A). Relevant cine frames were then projected on to a horizontal drawing surface to give an image of suitable known magnification ; twice life size was used. It was possible to determine the degree of magnification accurately as the actual length of the radio-opaque marker was known. A composite diagram was then constructed by tracing in over each projected image the exact position of the recording hole, as indicated by the radio-opaque marker, in relation to the diaphragm (Fig. 1 B). In the case of infants with a partial thoracic stomach it was possible to superimpose and sketch in accurately the situation and size of the intrathoracic gastric loculus by similarly projecting an appropriate cine film taken during the course of a barium examination (Fig. 1 C). In Fig. 1 D is shown the representational method adopted for the final recording and analysis of results.

RESULTS

It proved difficult to obtain recordings free from effects caused by extraneous influences such as crying and breath holding, secondarily induced by the withdrawal of the recording tube. Because of the technical difficulties encountered only six infants have been adequately studied. Three

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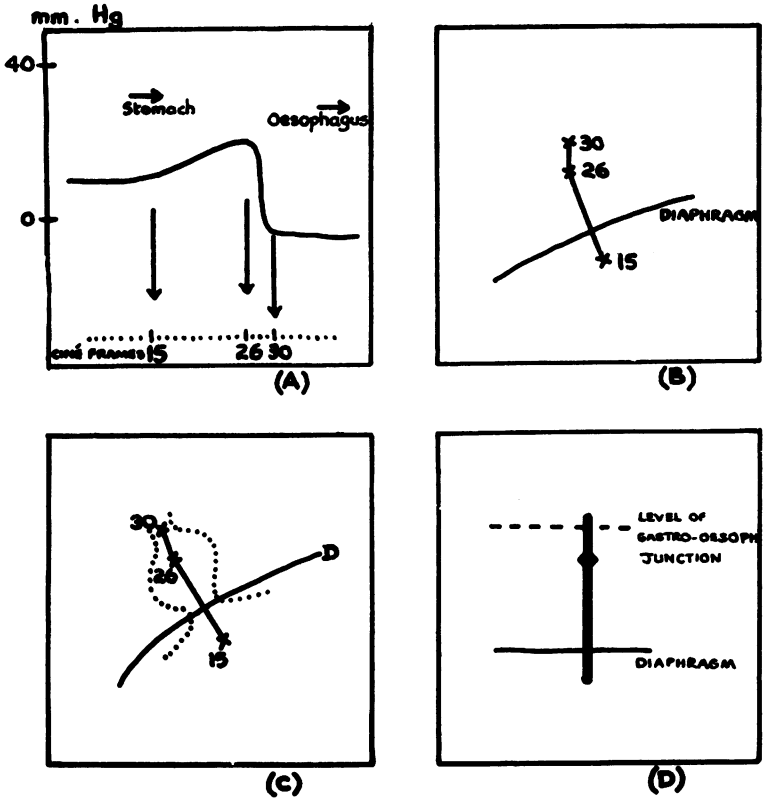


FIG. 1.—Diagram showing method of analysing and recording results. (A) Example of single gastro-oesophageal withdrawal pressure curve. (B) Tracing to known scale of projected image showing the situation of the pressure changes relative to the diaphragm. (The numbered points indicate the positions of the recording hole in frames 15, 26, and 30, i.e., at the sites where the pressure curve began to rise, where it began to fall, and where it reached intrathoracic level, as shown in A). (C) Barium outlines superimposed on pressure tracing from an infant with a partial thoracic stomach. (D) Representational method of recording results. The diamond indicates the point at which the pressure fall to intrathoracic level began, i.e., at frame 26. The lower and upper limits of the line indicate the sites at which the pressure rise began and at which the intrathoracic level was reached (frames 15 and 30).

(infants A, B, and C), aged 11, 9, and 4 months, had no radiologically demonstrable gastro-oesophageal abnormality; investigations were carried out during the course of an intubation undertaken primarily for the purpose of collecting duodenal enzymes. The other three (infants D, E, and F), aged 2, 11, and 1½ months, had (Fig. 2) a radiologically defined minor degree of partial thoracic stomach (Carré, Astley, and Smellie, 1952). Gastro-oesophageal reflux was noted in all three. Oesophageal narrowing due to either localized spasm or stricture formation was not seen. At the time of their investigation these latter patients were receiving medical treatment in hospital because of persistent and troublesome vomiting.

A total of 12 gastro-oesophageal withdrawal curves was obtained from the three infants with no radiologically demonstrable gastro-oesophageal abnormality. Pressure tracings obtained were either "saw-tooth" or "step" in type (Fig. 3). In seven curves there was an initial pressure rise above that in the stomach before the descent to intrathoracic pressure began (Fig. 4). A similar pressure rise was recorded in 54% of tracings, using a similar open recording system in adults with no demonstrable gastro-oesophageal abnormality (Botha *et al.*, 1957).

The site at which the descent to intrathoracic pressure began was at the level of or below the

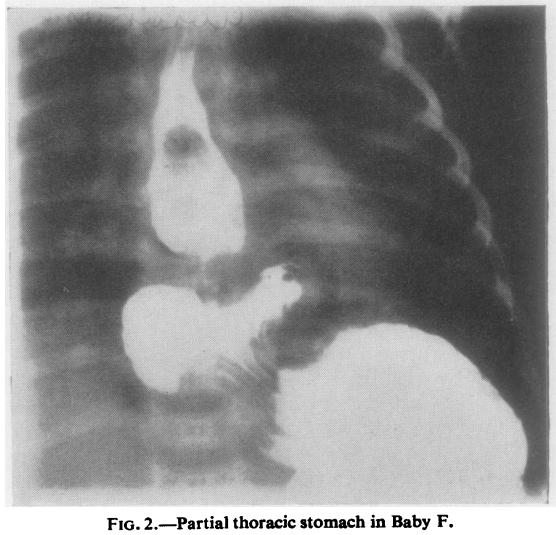


FIG. 2.—Partial thoracic stomach in Baby F.

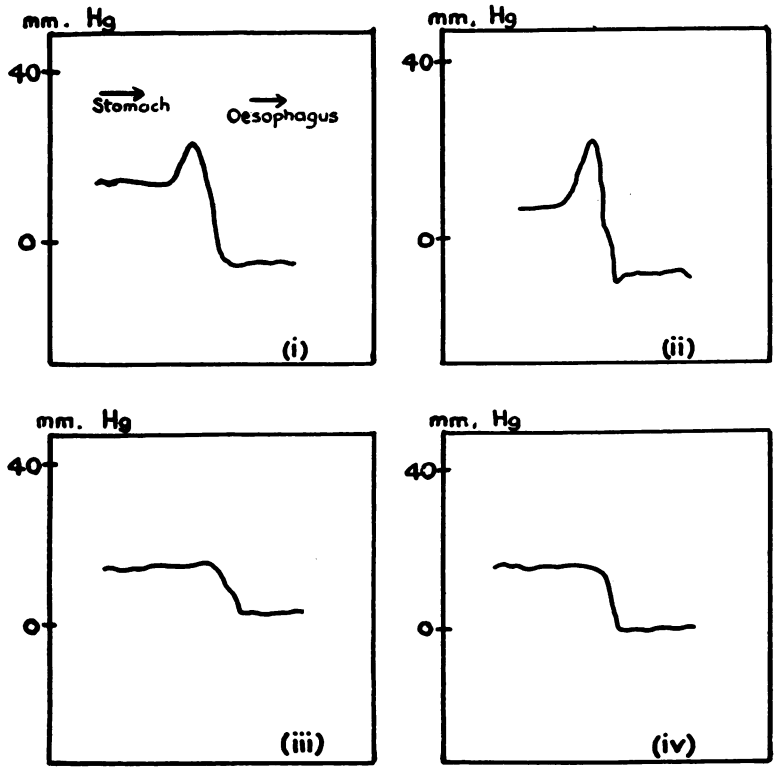


FIG. 3.—Types of withdrawal pressure curve obtained from infants with a normal gastro-oesophageal junction. (i), (ii): "Saw-tooth" type; (iii), (iv): "step" type curves. Curves (i) and (iv) were obtained from infant B, (ii) from C, and (iii) from infant A.

diaphragm in every instance, the mean position for the three infants being 0.4 cm. below the diaphragm. The site at which general intrathoracic pressure was reached was in six instances at or below the diaphragmatic level, the mean position for the three infants being only 0.05 cm. above the diaphragm. The total length of the segment over which pressure changes were recorded varied from 0.3 to more than 2.1 cm. with a mean in excess of 0.8 cm.

Eleven gastro-oesophageal withdrawal curves were obtained from the three infants with a partial thoracic stomach. These pressure tracings were identical in general appearance with those obtained in the three preceding infants and in adults. Similarly, in any one patient there were often variations in the type of pressure tracing obtained (Fig. 5).

In these patients it was possible to relate pressure changes not only to the diaphragm but also to the site of the radiologically defined gastro-oesophageal junction. In contrast to the results obtained in the other three infants, the site at which the descent to intrathoracic pressure began was at or above the diaphragmatic level in 10 of the 11 recordings, the mean value for the average position in each patient being 0.4 cm. above the diaphragm (Fig. 6). In every recording the site at which general intrathoracic pressure was reached was above the level of the diaphragm with a mean position of 0.9 cm. above. The latter position corresponded with the mean position of the gastro-oesophageal junction above the diaphragm. Pressure changes in these infants extended over segments varying in length from 0.2 to 1.6 cm. with a mean value of 0.9 cm.

DISCUSSION

Despite the few infants studied the results obtained from this investigation appear to us sufficiently consistent to justify definite conclusions.

In our previous study it was determined that pressure changes recorded in adults during the withdrawal of an open-ended recording tube from stomach to oesophagus were largely, if not entirely, independent of diaphragmatic action and favoured the existence of a lower oesophageal "sphincter" (Botha *et al.*, 1957). Similar recent views have been expressed by Fyke, Code, and Schlegel

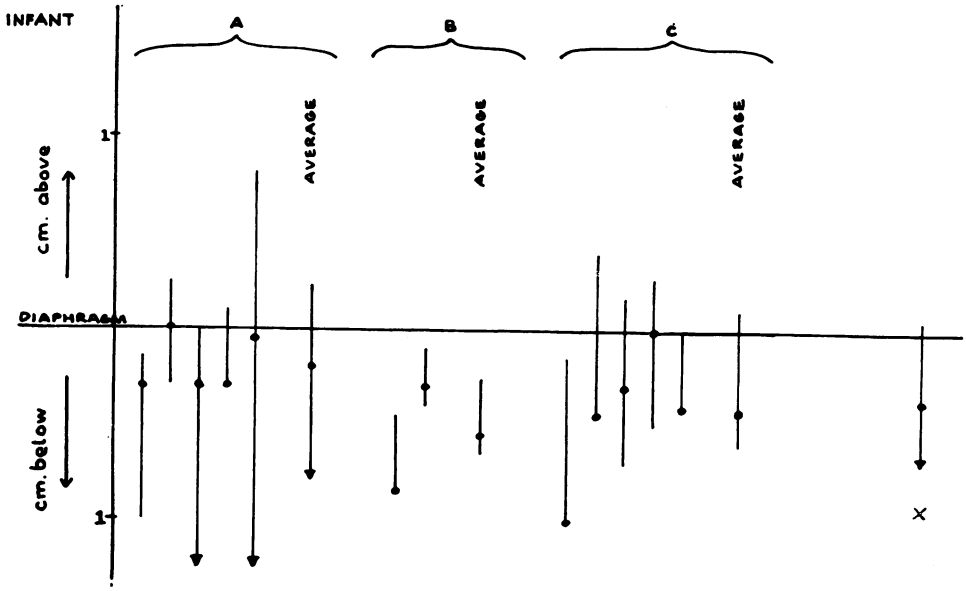
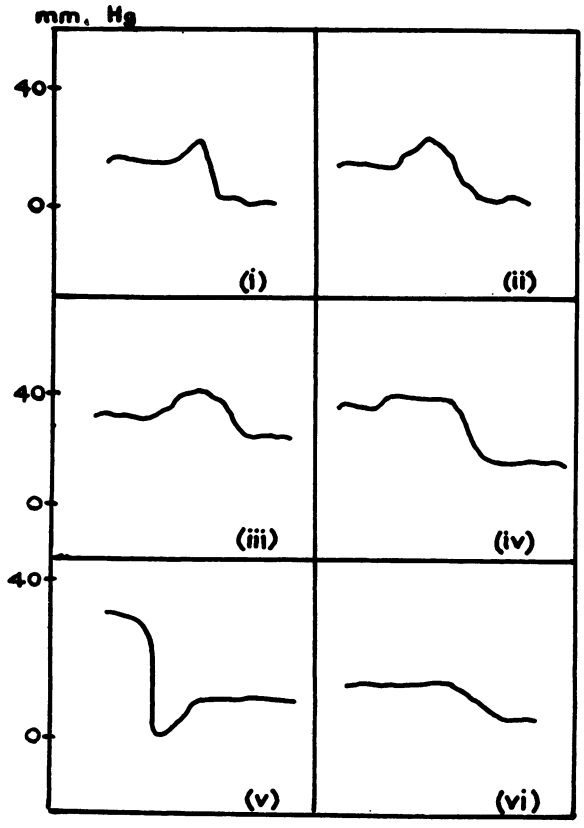


FIG. 4.—Situation of the pressure changes in three infants with a normal gastro-oesophageal junction. X is the mean of the three average results.



(1956), Braasch and Ellis (1956), and Atkinson, Edwards, Honour, and Rowlands (1957a and b).

Our present results show that gastro-oesophageal withdrawal pressure recordings in infants with no radiologically demonstrable gastro-oesophageal abnormality simulate in type those obtained from adults. Allowing for differences in size the relative length of segment over which pressure changes occur are also comparable. The recordings, however, differ with regard to the site at which changes in pressure take place, even allowing for differences in the size of subject. On average, changes in pressure occurred in infants at a relatively lower level in relation to the diaphragm. For example, whereas the average position at which the fall to general intrathoracic pressure began lay in the case of infants 0.4 cm. below the diaphragm, the comparable point in adults was 0.65 cm. above. Similarly, the points at which general intrathoracic pressure was reached were on average 0.05 and 2.15 cm. above the diaphragm in infants and adults respectively.

There are good reasons for believing the pressure changes recorded in both infants and adults to be related to the presence of a lower oesophageal "sphincter" (*vide infra*). The foregoing

FIG. 5.—Types of withdrawal pressure curves obtained from infants with a partial thoracic stomach. (i), (ii): "Saw-tooth" type; (iii), (iv): "plateau" type; (v), (vi): "step" type. Curves (i), (iii) and (iv) were obtained from patient D, (ii) and (v) from F, and (vi) from patient E.

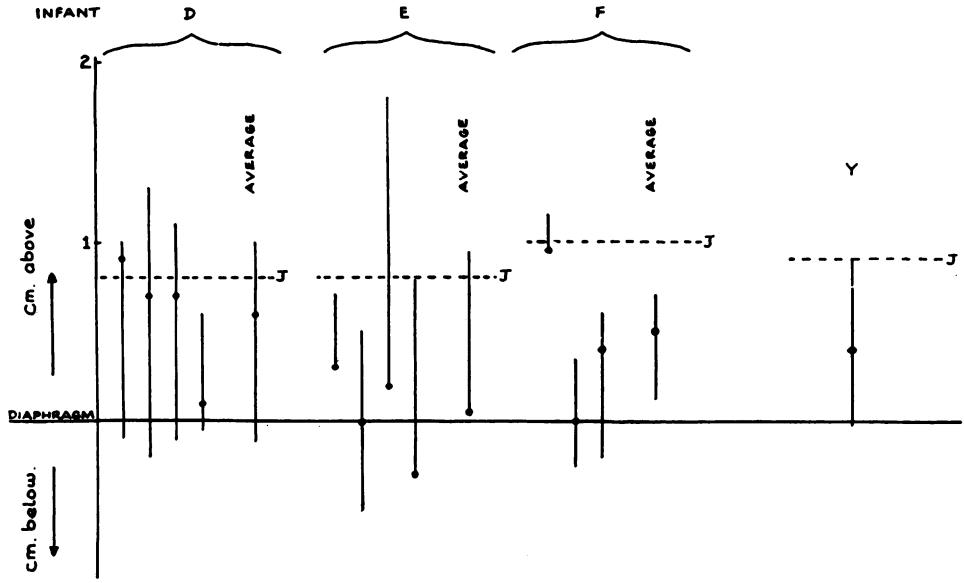


FIG. 6.—Situation of the pressure changes in three infants with a partial thoracic stomach. J is the level of the gastro-oesophageal junction; Y is the mean value of the three average results.

observations could, therefore, imply that by comparison with adults a relatively larger portion of the oesophagus in infants extends below the level of the diaphragm as defined radiologically. Alternatively, the findings could be explained by a discrepancy in the level of the hiatus and of the demonstrable part of the diaphragm. In the adult these two levels do not necessarily coincide exactly (Botha *et al.*, 1957 ; Botha, 1957 ; Monges, Monges, Gambarelli, Jouve-Fournier, and Dahl, 1957), and in the infant, whose diaphragm is often relatively high, such differences may possibly be exaggerated.

If the pressure changes noted in infants with no recognizable gastro-oesophageal abnormality were, in fact, produced by a lower oesophageal "sphincter," then it is reasonable to expect that similar pressure tracings would be obtained from infants with a partial thoracic stomach, provided the sphincter-like mechanism of the lower oesophagus was still operative. Theoretically, however, pressure changes in these latter patients should take place very largely within the thorax, corresponding in situation with the abnormally situated intrathoracic cardia. In fact, pressure recordings obtained from infants with a partial thoracic stomach were similar to those of infants with no gastro-oesophageal abnormality, both in respect of the type of pressure curve and in the length of segment over which pressure changes occurred. The pressure changes differed significantly, however, with regard to their situation and occurred principally within the thorax instead of below the diaphragm (Figs. 4 and 6). These observations may thus be interpreted as additional evidence for regarding the pressure changes recorded both in infants with and without a partial thoracic stomach as reflecting the existence of an intrinsic closing mechanism in the region of the cardia operating independently of the diaphragm.

The fact that gastro-oesophageal reflux was demonstrated in all three infants with a partial thoracic stomach would seem to imply that, though the sphincteric action at the lower end of the oesophagus is still operative, either this is considerably weakened or contributory mechanisms which in the normal infant assist in preventing gastro-oesophageal reflux are at fault in these patients, presumably as a result of the local anatomical displacement.

One additional feature of the recordings is of interest. The increase in pressure above that in the stomach which was recorded in about half the pressure curves obtained in adults has been interpreted as evidence of a compressing effect exerted by the lower oesophagus (Botha *et al.*, 1957). However, similar pressure changes recorded in infants with a partial thoracic stomach do not coincide as exactly as might have been expected with the situation of the lower oesophagus as defined radiologically (Fig. 6). The point of maximum pressure rise in these patients corresponds for the most

part with the lumen of the intrathoracic gastric loculus, i.e., with a point intermediate between the radiologically defined gastro-oesophageal junction and the diaphragm. This anomaly, however, may be more apparent than real. It is conceivable that the propulsive force exerted by the reflux of barium from below the diaphragm into the supradiaphragmatic loculus of stomach might cause an exaggerated temporary elevation of the gastro-oesophageal junction. As determined radiologically the gastro-oesophageal junction might thus appear half a centimetre or so higher than its actual position at the time of obtaining the withdrawal pressure tracings.

Summary

Six infants of under 12 months of age have been studied ; three had no radiologically demonstrable gastro-oesophageal abnormality and three had a minor degree of partial thoracic stomach. Simultaneous manometric and cineradiographic recordings were made on these infants while a pressure recording tube bearing a radio-opaque marker was withdrawn from the stomach into the oesophagus.

Pressure tracings obtained from infants of either group were identical in general appearance with those recorded in a similar previous study on normal adult subjects. In over half the recordings there was a zone of increased pressure immediately preceding the fall to general intrathoracic pressure. Both this zone and other changes in pressure occurred in infants with a partial thoracic stomach at a significantly higher level relative to the diaphragm and tended to correspond with the abnormally situated intrathoracic gastric loculus and cardia.

These observations have been interpreted as additional evidence for the existence of an intrinsic closing mechanism in the region of the cardia, operating independently of the diaphragm.

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