The anti-reflux mechanism after cardiomyotomy¹

R LOBELLO,² D A W EDWARDS,³ J W P GUMMER, AND M STEKELMAN

From the Surgical Unit, University College Hospital Medical School, the Department of Gastroenterology, Central Middlesex Hospital, London, and the Institute of Surgical Anatomy, 2nd Medical Faculty, University of Naples, Naples, Italy

Lobello, R, Edwards, D A W, Gummer, J W P, and Stekelman, M (1978). *Thorax*, 33, 569-573.
The anti-reflux mechanism after cardiomyotomy. Only 18 of 83 patients who had had a cardiomyotomy for achalasia could be induced to reflux barium. Mucosal herniation through the myotomy was shown in most by radiography. Perfusion manometry showed a higher pressure zone in the oesophagogastric junction region in 22 of 24 patients studied. This high pressure zone responded to an increment in abdominal pressure by a greater increment. The same response was seen in a patient with a small hiatal hernia and a myotomy. We conclude that the persisting high pressure zone seen by perfusion manometry is likely to be caused by the hiatus, and that the hiatus rather than the sphincter is likely to be responsible for the incremental response of the high pressure zone to increased abdominal pressure. The anti-reflux mechanism after cardiomyotomy is more likely to be the hiatal mechanism than persisting sphincter fibres.

A large proportion of our patients who have had a cardiomyotomy for achalasia do not have symptoms of reflux, and we are unable to show the capacity to reflux barium by radiology. Ellis and Cole (1965) made a similar observation and attributed the persistence of an anti-reflux mechanism to the hiatus. Atkinson (1959) and Ellis *et al* (1967) recorded a high pressure zone at the oesophagogastric junction in some subjects after cardiomyotomy, concluding that this high pressure zone was caused by persisting sphincter fibres and was the explanation of the lack of evidence of reflux.

The technique of myotomy used on our patients makes it unlikely that sphincter fibres persist and our purpose was to investigate the anti-reflux mechanism after such a cardiomyotomy. The hypotheses to be tested were (1) that an anti-reflux mechanism could be present in the total absence of any sphincter fibres and (2) that the oesophageal hiatus of the diaphragm was contributing to the high pressure zone.

Identification of this persisting anti-reflux mechanism may indicate how to prevent the

occasional development of reflux after cardiomyotomy.

Methods

(1) Manometry of the oesophagogastric junction was performed with 1 mm bore three- or four-lumen, side-hole, water-filled tubes, perfused at 0.4 ml a minute. The holes were either spaced 5 cm apart or at the same level, and the tube assembly was withdrawn in 0.5 cm steps from the stomach as the patient lay supine. The output of the transducer was recorded on heat sensitive paper through a Devices system.

(2) Radiographic evidence of the capacity to herniate stomach and to reflux barium was sought by one observer (DAWE) using a standardised anti-gravity barium swallow technique specifically designed for this purpose (Edwards, 1969). The technique also clearly showed any mucosal herniation through the myotomy. Reflux was quantified as (a) "slight"=a just visible trickle of barium, usually during the movement of rolling on to the right side; (b) "moderate"=clearly visible intermittent flow, which did not visibly increase the size of the oesophagus; and (c) "severe"=flooding of the oesophagus with visible increase in its size. This technique, in the hands of its author, has a reproducibility of better than 0.9.

¹A paper based on this study was read at the XX Biennial World Congress of the International College of Surgeons, Athens, 1976 (Califano *et al*, 1976).

²Professor R Lobello was in receipt of a European Science Exchange Program Fellowship.

³Work supported by the Medical Research Council.

(3) Operative techniques. Eighty-three patients had a standardised cardiomyotomy through the chest by one surgeon (JWPG) by the following technique. The lower oesophagus is mobilised out of the mediastinum. The muscular margin of the hiatus is retracted, and the peritoneum at the hiatus is divided so that the upper stomach can be drawn up into the chest. The myotomy extends upwards for 7–8 cm, downwards across the oesophagogastric junction, and on to the upper 2 cm of the stomach. These measurements are made when the viscus is stretched. Care is taken to make certain that all the circular muscle fibres are divided, allowing the mucosa to bulge freely through the myotomy. The stomach is allowed to slip back into the abdomen, and the cut edges of the oesophageal muscle are sewn to the hiatus. Care is taken not to damage the hiatus.

Results

RADIOGRAPHIC STUDIES

The patients were examined radiographically more than one year after cardiomyotomy. So far as possible patients are examined every two years indefinitely after operation. There is a trend towards finding evidence of hiatal herniation or reflux of barium more often as the time since myotomy increases; the results reported in this paper are of the most recent radiological examination. All patients examined by manometry had a radiographic examination at the same visit.

Capacity to herniate stomach or reflux barium

Of the 83 patients examined more than one year after the cardiomyotomy, at the latest examination four had a small hiatal hernia with "moderate" reflux, 14 had radiographic evidence of "slight" reflux in some manoeuvre but no evidence of herniation, and 65 had no evidence of the capacity to herniate or to reflux barium, nor had they at any previous examination.

Mucosal herniation At the time of the study, the last 46 consecutive patients had been examined specifically for evidence of mucosal herniation through the myotomy and this was clearly seen in 44 (fig 1). Evidence of mucosal herniation had not been consistently sought for or recorded in the preceding 37 patients. The size of the mucosal herniation was similar in almost all patients, about 3 cm long by 2 cm deep, measured after correction for image magnification. By a similar technique the preoperative sphincter segment was 1.75 to 2.0 cm long. This mucosal herniation extended to the hiatus indicating complete incision of the circular fibres at least to this level. From a consideration of the technique of myotomy, it

Fig 1 Mucosal herniation through myotomy. Silver clips were applied to ends of myotomy. Above fundus is partially emptied hiatal zone. Upper border of hiatus and dome of diaphragm form shelf-like filling defect at A.

seemed most unlikely that the effectiveness of the incision in severing the circular sphincter fibres was less in the hiatal and infrahiatal segment where the hiatus and crura prevent radiographic visualisation of herniation of mucosa. We concluded that in these patients the persistence of encircling sphincter circular muscle fibres was most unlikely. Of the 44 patients with documented mucosal herniation, six had evidence of "slight" reflux of barium compared with the total of 18 with reflux of barium out of 83. We concluded that a myotomy with known mucosal herniation did not materially increase the likelihood of reflux of barium.

MANOMETRIC STUDIES

There are two known components of the anti-

reflux mechanism, (a) the lower oesophageal sphincter and (b) the hiatus (Edwards, 1961). After cardiomyotomy the sphincter component is likely to be absent or weakened, and the supposed contraction response of the sphincter to challenge (Lind *et al*, 1966; Cohen and Harris, 1971) is likely to be prevented. The possibility that some circular fibres remain uncut and act effectively as a sphincter, without causing dysphagia, can be investigated by examining any patient who has the capacity to herniate the remains of the sphincter together with a loculus of the stomach through the hiatus. Two patients with this capacity were studied by manometry. An additional five patients with slight reflux of barium but no visible herniation were also studied and 17 patients without the capacity to herniate stomach or reflux barium. These 24 patients were chosen from consecutive patients seen in the routine follow-up clinic by (a) their willingness to co-operate in the study, (b) their ability to swallow and to retain the recording tube with equanimity, and (c) by our ability to get the end of the tube assembly into the stomach. They were all without significant dysphagia for solids or liquids and were all judged to have had a good clinical response to the myotomy. None had any symptoms of reflux. All had radiological evidence of mucosal herniation through the myotomy.

A high pressure zone was shown in 22 of 24 patients. The difference between maximum end-expiratory pressure and fundus pressure is shown in fig 2. The two patients who had a small hiatal hernia in the conditions of the manometric study had a high pressure zone. Four patients with "slight" reflux but no hernia had a high pressure zone. One patient did not have a high pressure zone nor a hiatal hernia but had "slight" reflux. In all patients the high pressure zone was immediately below the point of respiratory reversal, and we concluded that the latter corresponded to the upper margin of the hiatus in these circumstances. There was no response in this high pressure zone to swallowing.

Eight supine patients raised their straightened legs at each step in the withdrawal of the tube, and the maximal increment recorded in the high pressure zone was compared with that of the synchronous increment in fundal pressure. Paired values for each of at least three pull-throughs are plotted against each other after the manner of Cohen and Harris (1971) in fig 3. In each patient the increment in the high pressure zone was greater than the increment in fundal pressure. The graph (fig 3) is remarkably similar to that published by Cohen and Harris (1971).

Fig 2 Maximum end-expiratory pressure (with reference to fundus pressure) of oesophageal junction region of each of 24 patients after cardiomyotomy. Solid circle denotes a hiatal hernia was present. Mean of a total of 69 measurements on 24 patients = 9.78 cm water (0.98 kPa); SD = 5.86, SEM = 0.70.

Fig 3 Increment of abdominal pressure plotted against increment of "high pressure zone" pressure during straight-leg-raising for each of at least three pull-throughs on each of eight patients, after manner of Cohen and Harris (1971).

If it can be assumed that the sphincter fibres were cut the high pressure zone shown by perfusion manometry must reflect the presence of a zone of increased resistance to stretch caused by the hiatus. Habibulla (1972) reported evidence for a hiatal high pressure zone. The zone is capable of responding to a challenge of increased abdominal pressure by an incremental contraction or resistance to stretch, which is greater than the challenge. This evidence suggests that the incremental response of the high pressure zone previously reported by Lind *et al* (1966) and Cohen and Harris (1971) is mediated by the hiatus and not by the sphincter. We have suggested this previously on the basis of other evidence (Dilawari *et al*, 1974).

The crucial observation was that the same response was found in a patient with herniation of the sphincter and a small loculus of stomach, where any high pressure zone must have been caused by the hiatus alone. This patient (fig 4) refluxed barium when lying on her back or rolling

on to her right side, but did not reflux barium while straight-leg-raising, when the hiatus was seen to be contracted and to cut off the flow of barium across the hiatus. This evidence confirms our conclusion that the high pressure zone found after cardiomyotomy is more likely to be caused by hiatal than by sphincter contraction.

Pressure profiles of four patients obtained with a four-tube assembly with holes at the same level showed an asymmetry of the high pressure zone, with lower pressures being recorded anterior and posterior than left and right (fig 5). Circular sphincter fibres should show symmetrical, centripetal resistance to stretch. This asymmetry supports the suggestion that the hiatus caused the high pressure zone after cardiomyotomy.

Conclusions

Our conclusions are:

(1) That the common persistence of an anti-reflux mechanism after cardiomyotomy is unlikely to be dependent on a persistence of the sphincter fibres, and is likely to be dependent on a hiatal component. Conversely, the capacity for abnormal reflux after a cardiomyotomy is likely to reflect damage to this hiatal component. An essential part of a technique for cardiomyotomy, which does not result in reflux, is likely to be a preservation of this hiatal mechanism by care not to damage the hiatal attachments of the oesophagus, or an additional anti-reflux procedure.

(2) The so-called "sphincter response" to increased abdominal pressure seems to be the response of the hiatus and not the sphincter.

References

- Atkinson, M (1959). The oesophagogastric sphincter after cardiomyotomy. *Thorax*, **14**, 125-131.
- Califano, G, Lobello, R, Stekelman, M, and Edwards, D A W (1976). The anti-reflux mechanism after cardiomyotomy. Radiologic and manometric findings. International Congress series no 389, abstract no 175, International College of Surgeons, XX Biennial World Congress, Excerpta Medica, Amsterdam.
- Cohen, S, and Harris, L D (1971). Does hiatus hernia affect competence of the gastro-oesophageal sphincter. *New England Journal of Medicine*, **284**, 1053-1056.
- Dilawari, J B, Edwards, D A W, and Girmes, D H (1974). The probability of symptoms or of radiographic evidence of reflux predicted by lower oesophageal sphincter pressure. In *Proceedings of 4th International Symposium on Gastrointestinal Motility*, edited by E E Daniel, pp 441-448. Mitchell Press, Vancouver.

Fig 4 Pressures developed during "straight-leg-raising." Three infused tubes with side holes 5 cm apart, with two openings into abdominal stomach and one at hiatus in a patient with a cardiomyotomy and a small hiatal hernia.

Fig 5 Record obtained with a four-lumen tube with holes at same level, 90° to each other. There is asymmetry of pressure in "high pressure zone" extending over several cm because zone moves about 2 cm over recording holes with respiration. Each vertical line represents withdrawal of 0.5 cm of the tube from nostril but in achalasia this does not necessarily mean 0.5 cm at the hiatus.

Edwards, D A W (1961). The mechanism at the cardia. The anti-reflux mechanism. *British Journal of Radiology*, **34**, 474-487.

Edwards, D A W (1969). Diaphragm and hiatus hernia. In *Textbook of X-Ray Diagnosis*, 4th edition, vol 4, edited by S G Shanks and P Kerley, pp 266-319. P Lewis, London.

Ellis, F, and Cole, F L (1965). Reflux after cardiomyotomy. *Gut*, **6**, 80-84.

Ellis, F H, Kiser, J C, Schlegel, J F, Earlam, R J, McVey, J L, and Olsen, A M (1967). Esophagomyotomy for esophageal achalasia: experimental,

clinical and manometric aspects. *Annals of Surgery*, **166**, 640-656.

Habibulla, K S (1972). The diaphragm as an anti-reflux barrier. *Thorax*, **27**, 692-702.

Lind, J F, Warrian, W G, and Wankling, W J (1966). Responses of the gastro-oesophageal junctional zone to increases in abdominal pressure. *Canadian Journal of Surgery*, **9**, 32-38.

Requests for reprints to: Dr D A W Edwards, Surgical Unit, Rayne Institute, University College Hospital Medical School, London WC1E 6JJ.