

Proximal stomach and antrum in stomach emptying

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SUMMARY In a series of measurements of liquid-phase gastric emptying using a radionuclide marker on 35 subjects, five were identified in whom the proximal stomach and antrum were clearly distinguishable. Three of these subjects were normal controls and two suffered from systemic sclerosis. In the three normal subjects, analysis of the movement of the liquid showed the expected movement from fundus to antrum and thence through the pylorus. In the two patients with systemic sclerosis, there was, in contrast, evidence of mass retropulsion of the contents of the antrum into the fundus. In such cases, the measurement of stomach emptying based on the assumption of a single-compartment system is likely to be misleading.

In recent years the measurement of stomach emptying of both liquids and solids by means of radionuclide-labelled meals and gamma camera imaging systems has become widely established (Sheiner, 1975). Although it is generally accepted that the total emptying curve cannot be adequately described in terms of a simple function—for example, monoexponential (Barber *et al.*, 1975)—it is still frequently assumed that the stomach behaves as a single compartment which fills instantaneously and empties unidirectionally into the small bowel.

In the course of a study of gastric emptying in patients with systemic sclerosis, it became apparent that there existed a number of patients in whom these assumptions could not be sustained.

Method

Gastric emptying was studied with the patient in a near-erect posture, partially supported by a stool but with both feet on the ground. The drink used for the test had a volume of 200 ml, of which 28 ml was lactulose syrup, the volume being made up with tap-water. $^{99}\text{Tc}^m\text{-DTPA}$ (250 μCi) was used as a label for the liquid meal (Chaudhuri, 1974). The test was carried out in the early afternoon, the subjects having fasted from midnight the previous night. The stomach was imaged using a Nuclear Enterprises Mark III gamma camera. Data were collected and stored on a PDP-11 computer (Digital Equipment Corporation) in the form of 30 one-minute frames, collection being started when the patient began to drink.

From a group of 35 subjects, three controls with

no suspected gastrointestinal pathology and two patients with systemic sclerosis were found in whom a clearly distinguishable antrum and proximal stomach were seen on imaging. The stored data were analysed by selecting a region of interest to include the stomach image and plotting the change in detected count-rate against time. In addition the early images (0-10 minutes) were used to delineate proximal stomach and antrum, and curves corresponding to these areas were plotted.

Results

Although considerable variation in the shape, size, and position of stomach images was observed from one subject to another, the majority conform to the typical 'J' shape as seen in Fig. 1 (a). In each of the five patients discussed here, however, two distinct areas of the stomach could be identified, corresponding to the proximal stomach and the antrum. The appearances ranged from that shown in Fig. 1 (b), to the extreme example of Fig. 1 (c). This latter form could reasonably be described in terms of the 'cup and spill' configuration familiar to radiologists both as a normal variant and in association with disease states (Keller *et al.*, 1975).

In the three control subjects, movement of the liquid was, as expected, from the proximal stomach into the antrum and likewise out into the duodenum, demonstrating an open two-compartment (catenary) system (Veall and Vetter, 1958). This is shown in Fig. 2.

The two systemic sclerosis patients, however, showed evidence of retropulsion of part of the contents of the antrum into the proximal stomach as

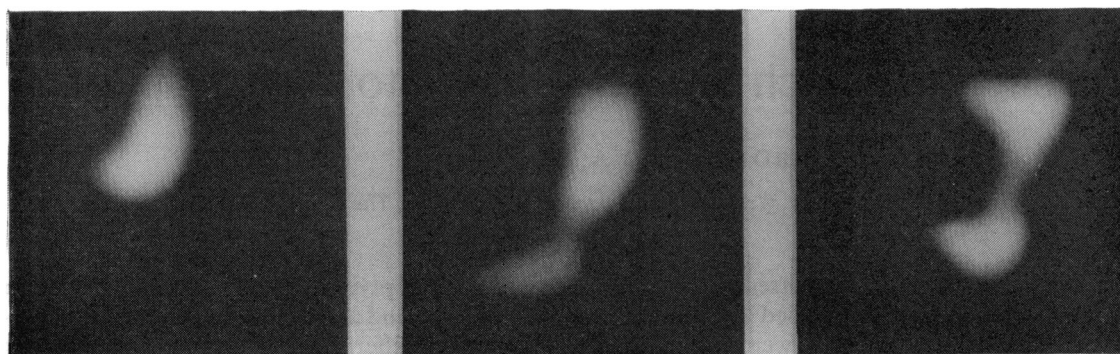


Fig. 1 Examples of observed stomach configurations. (a) Typical 'J' shape. (b, c) Two distinct regions.

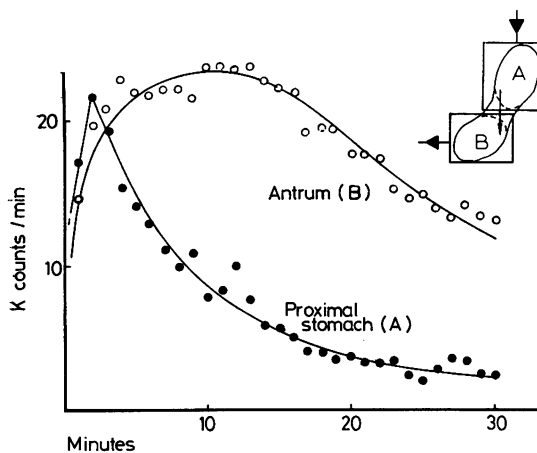


Fig. 2 Two-compartment stomach emptying in control subject.

shown in Fig. 3. It was also possible in both subjects to observe changes in the imaged stomach shape at times corresponding to the changes in the activity-time curves.

Discussion

With regard to its motility, the stomach has been considered to consist of two functional regions (Kelly, 1974a): the proximal stomach, comprising the fundus and most of the body, and the antrum. Although contractile impulses originate in the former, they are much weaker there than in the latter (Davenport, 1971). As a result, the proximal stomach is generally regarded as a relatively inactive reservoir, with most of the mixing and peristaltic activity occurring in the antrum. Co-ordinated antro-duodenal contraction and relaxation result in

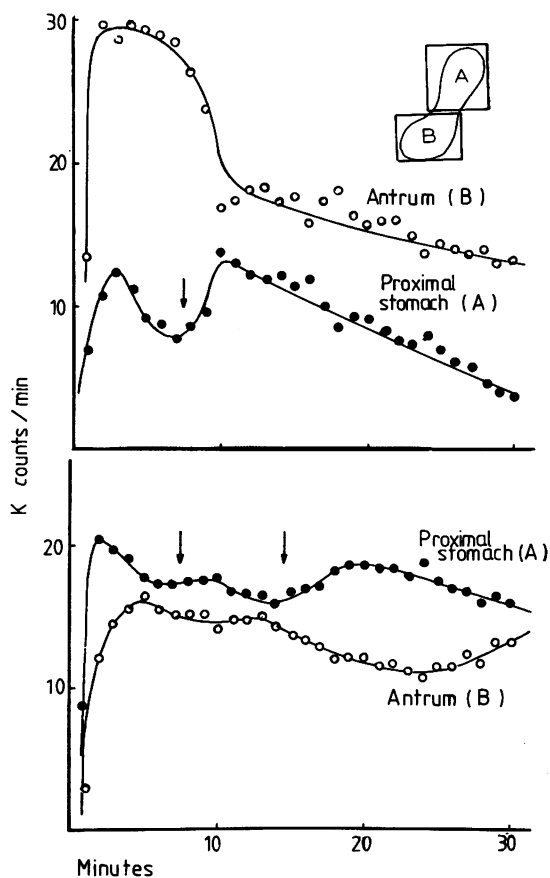


Fig. 3 (Top and bottom). Two-compartment stomach emptying in subjects with systemic sclerosis showing mass repulsion. (Onset of repulsion indicated by arrows.)

the emptying of fluids through the pylorus but the antral contractions are also thought to lead to movement of contents back into the proximal stomach, a phenomenon known as 'retropulsion' (Kelly, 1974b) which contributes to the mixing process. The mechanism has been well described in the canine stomach (Carlson *et al.*, 1966).

Our finding of two clearly defined anatomical regions on radionuclide imaging of the stomach is, therefore, not unexpected, although we have observed it in only 14% of subjects studied so far. Likewise, our observation of mass retropulsion is not altogether surprising, although one might suppose that in subjects taking a liquid meal in an upright posture the return of retropelled liquid to the antrum would be too rapid a process to be detected by measurements at one image-frame per minute.

It is tempting to relate the retropulsion observed in systemic sclerosis to some aspect of the altered gastrointestinal motility which occurs in this disease, although gastric involvement is relatively uncommon (Tuffanelli and Winkelmann, 1961). The phenomenon we have observed might then be evidence of a pathological process rather than a physiological one. It could, for example, contribute to the symptoms of gastro-oesophageal reflux which frequently trouble such patients. However, the numbers are too small for any definite conclusions to be drawn, and it may subsequently prove to be coincidental that the effect was seen only in the systemic sclerosis patients.

Alternatively, when physiological retropulsion occurs in association with an anatomical 'cup and spill' gastric configuration, the return of the liquid to the antrum from the 'cup' might be sufficiently delayed to become apparent on imaging. This begs the question as to why it was not also evident in the control subjects. None of the subjects studied had a hiatus hernia, so temporary trapping of the liquid in such a hernia can be excluded as an explanation for the findings.

Conclusion

Whatever the reason for the difference between the controls and the patients with systemic sclerosis, it is apparent that in these five subjects the stomach cannot be regarded as a single-compartment system. Hence the description of stomach emptying in terms

of the simple half-emptying time is likely to provide an incomplete account of the observed events. Moreover, variation in intragastric distribution of contents such as we have observed could be one of the reasons why total emptying curves do not always conform to a simple function, as gastric motility is related to the degree of distension (Hunt and MacDonald, 1954).

It would seem to be desirable that whenever such a two-compartment configuration is seen, the appropriate regions should be examined in detail, and not merely the total gastric area.

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