Is there an antral-body portal system in the stomach?

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SUMMARY The direction of blood flow from the gastric mucosa of the antrum of the rat stomach has been studied using the isotope Rb$^{86}$Cl. In a series of five experiments radioactivity has been shown to be transported via the blood stream from the antrum to the parietal cell mass without passing through the general circulation first. It is suggested that a 'portal' or direct transport system from antral mucosa to the body of the stomach exists.

It is not definitely known how gastrin is transported from G cells in the antrum of the stomach to act on the parietal cell mass. Menguy (1962) introduced the concept of redistribution of gastric mucosal blood flow within the organ in response to secretory stimulants and suggested that the antrum may control blood flow to the body of the stomach. It had been suggested earlier that removal of the antrum reduced blood flow to the body of the stomach (Waddell and Williams, 1959). A convenient method of transport for gastrin would be a direct one from antrum to body in the mucosal blood stream, and in view of this hypothesis our aim has been to investigate the direction of blood flow within the gastric mucosa, with particular interest in the relationship between the antrum and the parietal cell mass. This problem has been investigated by carrying out five groups of experiments in a rat model.

Materials and Methods

A method of measuring blood flow, to all organs other than the brain, by assessing the fractional distribution of several radioactive indicators has been described by Sapirstein (1958), and has been applied to the measurement of gastric mucosal blood flow (Delaney and Grim, 1964, 1965; Guth, 1972). The isotope Rb$^{86}$Cl, which is extracted from the blood stream by the adjacent tissues in one circulation, has been used in this study. We have shown that following intramucosal injection this isotope is detectable in tissues which receive blood directly from the site of injection.

Experiment I

In the first series of experiments six Wistar rats, weighing between 175 and 225 grams and starved for 48 hours, were anaesthetized with a mixture of halothane, nitrous oxide and oxygen. A longitudinal gastrotomy was made close to the greater curvature and an intramucosal injection of a minute droplet of a solution of Rb$^{86}$Cl was made in the antrum well away from the clearly demarcated antral-body junction (fig 1). Great care was taken to prevent the isotope from spilling. Sixty seconds later, about one circulation time in the rat, the animal was killed with an intravenous injection of KCl. The whole of the stomach and liver were excised and the antrum was removed at the antral-body junction. The radioactivity in these organs was determined by counting in a Panax scintillation counter.

Fig 1 Experiment I: injection into the antral mucosa.
Experiment II

In a similar group of six rats all blood vessels supplying and draining the stomach were occluded by clamps to arrest the gastric circulation and the experiment was otherwise carried out in exactly the same way as in experiment I.

Experiment III

In a third group of six rats the stomach was divided at the antral-body junction and none of the major feeding vessels along the curvatures was interrupted. The isotope in similar quantity was injected into the antrum and the animal was again killed after 60 seconds (fig 2). The antrum and body of the stomach, liver and remaining rat tissues were counted.

Experiment IV

In the fourth group isotope was injected into the mucosa of the body of the stomach (fig 3), the reverse procedure to that of experiment I; otherwise this experiment was conducted in an exactly similar manner.

Experiment V

In a fifth group of six rats the experiment was conducted in exactly the same way as experiment I, the radioactivity being injected into the antrum. The body of the stomach, the duodenum and a strip of terminal ileum were excised for counting after killing the animal.

Results

Experiment I

The total activity in the body of the stomach, the liver, and the remaining rat tissue are represented in fig 4 (each symbol represents an individual rat). These results illustrate that activity was transferred from the antrum to the body of the stomach in all rats. Activity recorded within the liver must have been transmitted by the blood stream either from the antrum directly or via the body of the stomach. The total activity in the remaining 200 grams or so of rat tissue, counted under the same conditions is small and per gram of tissue, compared with the body of the stomach, the activity would be less than 1% of that recorded in figure 4. We would infer that activity was transferred directly from the antrum to the body of the stomach without passing through the general circulation first.

The absolute counts of activity from one rat to another are not strictly comparable. The activity recorded in the various experiments is an indication...
of directional blood flow from the site of injection and not an indication of relative quantitative blood flow.

**Experiment II**
To exclude simple diffusion of isotope across the antral-body junction as opposed to transfer within a network of mucosal vessels the second experiment was carried out. After occlusion of all the blood vessels supplying and draining the stomach fig 5, in similar format to fig 4, shows that virtually no activity was detectable in the body of the stomach following the same dose of injectate. This is in marked contrast to the results of experiment I, suggesting that the transfer of activity from the antrum to the body of the stomach is dependent upon the flow of mucosal blood.

**Experiment III**
Following antral exclusion virtually no activity was transferred to the body of the stomach but the liver and total rat counts were of a similar order to those in the first experiment (fig 6).

**Experiment IV**
When isotope was injected into the body of the stomach some activity could be detected in the antrum but uniformly less than was transferred from antrum to body in the first experiment. The activity recorded in the liver and remaining rat tissue was again of a similar order (fig 7).

**Experiment V**
Following the injection of isotope into the antrum of the stomach radioactivity could always be recorded in the duodenum but uniformly less than was recorded in the body of the stomach. On no occasion was the activity recorded in the terminal ileal segment significantly above the background level (fig 8).

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![Fig 5](http://gut.bmj.com/)
**Fig 5** Experiment II: relatively little isotope is transferred from the antrum when the blood supply is arrested.

![Fig 6](http://gut.bmj.com/)
**Fig 6** Experiment III: after antral exclusion the transfer of isotope to the parietal cell mass is interrupted.

![Fig 7](http://gut.bmj.com/)
**Fig 7** Experiment IV: activity is transferred from the parietal cell mass to the antrum.

![Fig 8](http://gut.bmj.com/)
**Fig 8** Experiment V: some radioactivity is transferred directly to the duodenum through the lattice work of vessels but less than is transported to the parietal cell area of the stomach.
The mean dosage of the intramucosal injection in experiments I-IV was 470, 411, 545 and 359 counts per second respectively.

Discussion

Menguy (1962), using an electromagnetic flowmeter and an 1185 clearance technique to measure gastric blood flow, found that secretory stimulants altered the antral body flow. He introduced the concept of redistribution of blood within the organ in response to stimulants and suggested that the antrum may control blood flow to the body of the stomach. Waddell and Williams (1959), using a bubble flowmeter, had earlier suggested a relationship between flow rates of the antrum and body. They found that removal of the antrum reduced the blood flow to the body of the stomach and suggested that this was due to the interruption of long afferent pathways to the hypothalamus. Barclay and Bentley (1950) and Nylander and Olerand (1961) have studied the microvasculature of the gastric mucosa using microangiographic techniques but to date no studies have been carried out on the direction of flow through the gastric mucosa.

These findings suggest that a 'portal system' exists between the antrum and body of the stomach in the rat, so that substances present in one part of the stomach may be directly transported to another. In effect gastrin secreted by the G cells in the antral mucosa could pass directly to the body of the stomach, to act in relatively undiluted concentrations on the parietal cell mass, the target organ. This would appear to be a more convenient pathway for this hormone to act as otherwise its concentrations on reaching the oxyntic cell would be greatly diluted by the systemic circulation and by excretion in the liver, kidney and small intestine. Stagg, Temperley, and Wyllie (1971) have shown that the liver is the major site of excretion of this hormone and the portal system postulated would clearly obviate its passage through this organ before acting on the target cell.

These findings are supported by the observations of Barlow, Bentley, and Walder (1951) who stated that 'the whole of the blood supply of the stomach and bowel might be regarded as one large latticework of vessels which are fed at fairly constant points by the named arteries and which could permit blood flow to be directed toward, or away from, any particular area if suitable conditions of vessel control existed'.

References