

# Tubeless gastric analysis with a radio-telemetering pill (Heidelberg capsule)

M. R. ANDRES, JR., M.D. and J. R. BINGHAM, M.D., F.R.C.P.[C], Toronto

The standard method today for measuring gastric acid secretion is the augmented histamine stimulation test of Kay<sup>1</sup> in which gastric secretion is aspirated through a nasogastric tube one hour before and again one hour after the administration of histamine diphosphate 40  $\mu$ g. per kg. body weight, betazole HCl (Histalog; Eli Lilly) 1.5-2.5 mg. per kg. or pentagastrin 6  $\mu$ g. per kg. Histalog is frequently substituted for histamine, as it eliminates the need for an antihistaminic drug to counteract the non-gastric side effects of this large dose of histamine. Pentagastrin is a new synthetic gastrin-like pentapeptide which is more potent than histamine but has the same acid-secreting properties without the histamine side effects.<sup>2</sup> Unfortunately a disadvantage of the standard gastric analysis using one of these stimuli is that it requires the introduction of an indwelling nasogastric tube which many patients find most disagreeable. Furthermore, it is difficult or impossible to ensure complete removal of all secreted gastric juice unless continuous hand aspiration is done,<sup>3</sup> and this is time-consuming and therefore costly. These objections are largely overcome by the use of a radiotelemetering pH pill, the

Heidelberg pH capsule, to measure acid secretion.

In this report we describe the method for measuring gastric acid secretion with the Heidelberg pH capsule and compare the results with those obtained by the standard aspiration test of Kay using Histalog as the stimulus. We wish to confirm the findings of Stavney *et al.*,<sup>4</sup> Yarbrough *et al.*<sup>5</sup> and Stack<sup>6</sup> that the capsule method gives results comparable to those obtained by the standard aspiration technique and that it is a simple method of measuring acid secretion causing very little discomfort to the patient.

## Materials and methods

The Heidelberg pH capsule contains a miniaturized radio transmitter, a pH meter, and a battery enclosed in an indigestible acrylic container measuring 20 x 7 mm. (Fig. 1).<sup>\*</sup> The battery is activated by immersion in saline just before the test. The pH-measuring cell consists of an external annular antimony electrode and an internal silver chloride electrode, the two being separated by a semi-permeable membrane. The pH changes alter the output voltage of the battery, which in turn controls the frequency emission of the radio transmitter. The radio frequencies are picked up by an antenna which is strapped around the subject's waist and then recorded on both a dial and graph paper in a transistorized receiver (Fig. 2).

The Heidelberg pH capsule has been critically evaluated and its accuracy determined by a number of workers.<sup>7-10</sup>

## Calculation of acid secretion

The use of the capsule to measure the amount of acid secreted can best be described by comparison with the conventional method of measuring acid using aspirated gastric juice. In the latter the concentration of acid is obtained by titrating an aliquot of filtered gastric juice with N/10 NaOH to pH 3 or 7, the end point being determined by Töpfer's reagent or a pH meter. The amount of acid is then calculated by multiplying the concentration by volume secreted.

With the Heidelberg pH capsule the titration is done inside the

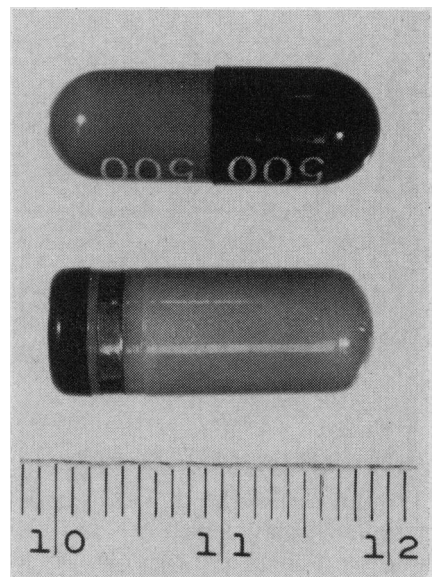


FIG. 1—The size of the Heidelberg capsule compared with ampicillin capsule.

From the Gastrointestinal Research Unit, Toronto Western Hospital and the University of Toronto, Toronto, Ontario. This study was supported by a grant from The Watt Research Fund.  
M. R. ANDRES, JR., M.D., Fellow in Gastroenterology, Toronto Western Hospital.  
J. R. BINGHAM, M.D., F.R.C.P.[C], Assistant Professor of Medicine, University of Toronto.

Reprint requests to: Dr. J. R. Bingham, Toronto Western Medical Building, 25 Leonard Avenue, Toronto 2B, Ontario.

\*Medintron Corporation of America, 42 Broadway, New York, N.Y.

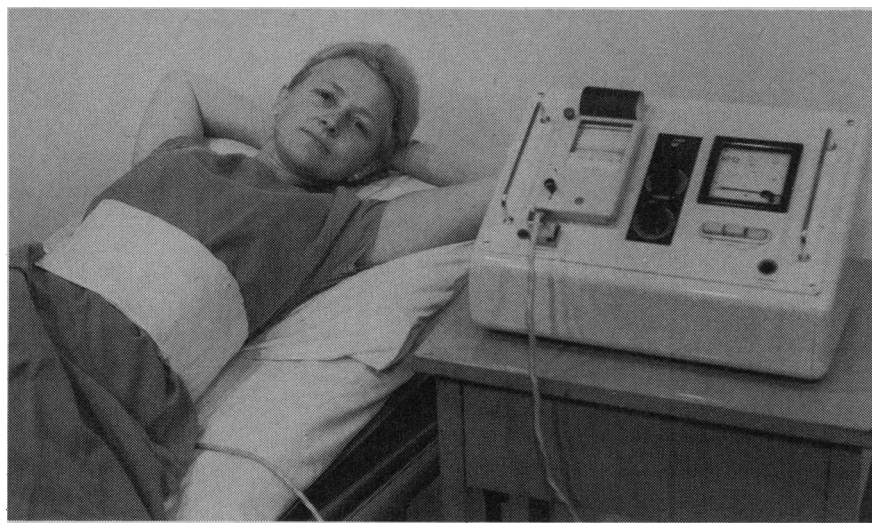


FIG. 2—Belt antenna and receiver.

stomach while the pH is being continuously monitored. The neutralizing alkali was  $\text{KHCO}_3$  made up so that 1 ml. contained 1 mEq. of alkali and it was given in 20 ml. water. Sufficient alkali was given to raise the pH to about 7 for 5 to 15 minutes; when the pH dropped below 3, more alkali was given. The number of ml. of alkali required to neutralize the gastric secretion equals the amount of acid secreted in milliequivalents. The first drink usually contained about 2 ml. (2 mEq.) of alkali and the duration of the neutralizing response gave some indication of the gastric secretory activity and the amount of alkali to be given in subsequent titrations. A typical recording is shown in Fig. 3.

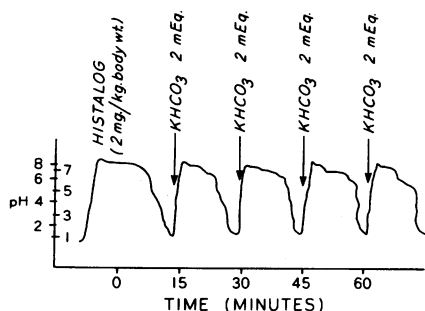


FIG. 3—Typical pH recording from a patient without disease.  $\text{KHCO}_3$  given at times shown by arrows. Total acid secretion was 8 mEq. in the hour after administration of Histalog.

#### Determining position of capsule

The position of the capsule was determined radiologically. In the average patient the capsule was at the mid-point of the stomach when 55 cm. of the thread had passed

the incisor teeth. The pH of the esophagus and the duodenum was usually above 6,<sup>11</sup> whereas that of the stomach was usually below 3, so that a steady pH recording below 3 indicated that the capsule was in the stomach. A small amount of neutralizing alkali was then given, and an immediate rise in pH confirmed that the capsule had not left the stomach. When the subject had achlorhydria or a very low acid secretion, this method could not be used. The fact that the capsule had not left the stomach was then confirmed by giving a small amount of dilute HCl and observing an immediate drop in pH.

Originally the capsule was swallowed in the free state with the patient lying on the left side and the foot of the bed raised on six-inch blocks. However, five of the first 12 capsules passed into the duodenum before the test was completed, so we then attached a 4-0 silk thread to the capsule. The thread was not uncomfortable and had the additional advantage that the capsule could be recovered, washed and dried and re-used. (In this study a fresh capsule was used for each subject.) Using the thread, the subject lay on the left side but the recording could be done in the sitting position and he could walk around between periods of recording. Saliva was expectorated.

Basal acid secretion was measured for a half-hour period. Histalog 2 mg. per kg. body weight was then given by subcutaneous injection and the acid secretion was measured over the next hour.

Gastric acid secretion was also measured in each subject by the aspiration method not less than two days before or after the capsule study, using the same amount of Histalog. Continuous hand aspiration of secreted gastric juice was done to ensure complete recovery. In order to measure the degree of recovery, 3.6 mg. of phenol red in solution was dripped into the stomach during each 15-minute collection period through a separate nasogastric tube. From the percentage recovery of phenol red could be calculated the proportion of gastric juice recovered by aspiration. Not all phenol red is recovered; some is lost by absorption through the gastric mucosa or by sequestration in the mucosal folds. It has been estimated that up to 10% of an initial instillation of phenol red is lost in this way but that less than 5% of a subsequent instillation is lost.<sup>12</sup> In order to minimize this initial loss we administered a drink of phenol red half an hour before the commencement of the test. Our average recovery of phenol red was 97.3%, with a range of 80 to 100% for individual subjects.

TABLE I  
Comparison of One-hour Post-histalog Acid output measured by Aspiration of Gastric Juice through a Nasogastric tube and by the Heidelberg Capsule

Subject No.	Aspiration (mEq.)	Capsule (mEq.)	Difference (mEq.)
1	18	30	+12
2	42	35	-7
3	29	31	+2
4	28	32	+4
5	29	52	+23
6	60	34	-26
7	8	12	+4
8	35	46	+11
9	11	10	-1
10	28	40	+12
11	1	1	0
12	8	18	+10
13	30	22	-8
14	54	76	+22
15	31	52	+21
16	19	22	+3
17	17	10	-7
18	18	28	+10
19	20	37	+17
20	50	30	-20
21	23	14	-9
22	22	28	+6
23	23	27	+4
24	34	25	-9
25	38	22	-16
26	21	32	+11
27	28	40	+12
Mean	27	30	+3

## Results

Measurements of the one-hour post-Histalog acid secretion by the capsule and the aspiration methods were compared in 27 unselected subjects. Of these, seven had duodenal ulcer; five had dyspepsia without radiological abnormality, three had gastric ulcer; one had a duodenal ulcer and had undergone vagotomy and pyloroplasty; and 11 had no disease.

Comparison of the acid values obtained by the capsule and the aspiration methods showed acceptable agreement, with a correlation

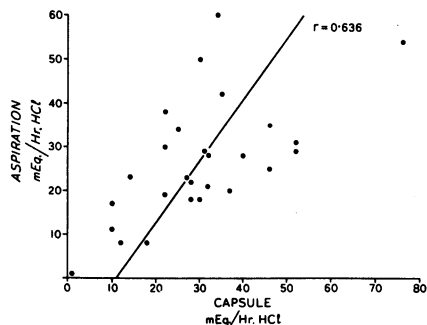


FIG. 4—One-hour post-stimulus acid secretion measured by the Heidelberg capsule (horizontal line) and by the aspiration method through a nasogastric tube (vertical line) for each of the 27 subjects.

coefficient of 0.68 (Fig. 4). The capsule method gave slightly higher mean acid measurements than did the aspiration method. The mean acid secretion determined by the capsule method was 30 mEq. (s.d. 15.2) and by the aspiration method it was 27 mEq. (s.d. 13.6), but there was no significant difference between these two means ( $P = 0.5$ ). For the individual subjects the capsule method gave higher values than the aspiration method, 16 subjects having a higher value and 11 subjects a lower one (Table I).

## Conclusion

One-hour post-stimulus (Histalog 2 mg. per kg. body weight) gastric acid secretion was measured in 27 subjects by means of the Heidelberg pH radiotelemetering capsule and compared with the results obtained by the standard aspiration technique of Kay.

Sixteen subjects showed higher secretory values with the capsule method and 11 showed higher levels with the aspiration method. In some subjects the secretory

values obtained by the two methods differed significantly. However, the results based on mean values obtained by the capsule method were similar to those obtained by the standard aspiration technique.

The capsule method was simpler to do and caused only minimal discomfort.

We wish to acknowledge the valuable technical assistance of Mrs. Orythia Johnston.

## References

1. KAY, A. W.: *Brit. Med. J.*, 2: 77, 1953.
2. MAKHLOUF, G. M., MCMANUS, J. P. AND CARD, W. I.: *Gastroenterology*, 51: 455, 1966.
3. JOHNSTON, D. H. AND MCGRAW, B. H.: *Ibid.*, 35: 512, 1958.
4. STAVNEY, L. S. et al.: *Amer. J. Dig. Dis.*, 11: 753, 1966.
5. YARBROUGH, D. R. et al.: *Amer. J. Surg.*, 117: 185, 1969.
6. STACK, B. H.: *Gut*, 10: 245, 1969.
7. NÖLLER, H. G.: Clinical application of telemetering techniques. In: International Conference on Medical Electronics, third, Proceedings, London, July 21 to 27, 1960, International Federation for Medical Electronics, London, 1961, p. 111.
8. CONNELL, A. M. AND WATERS, T. E.: *Lancet*, 2: 227, 1964.
9. STEINBERG, W. H. et al.: *J. Pharm. Sci.*, 54: 772, 1965.
10. WATSON, W. C. AND PATON, E.: *Gut*, 6: 606, 1965.
11. AYNACIYAN, A. V. AND BINGHAM, J. R.: *Gastroenterology*, 56: 476, 1969.
12. BLOOM, D. S., JACOBSON, E. D. AND GROSSMAN, M. I.: *Ibid.*, 52: 205, 1967.

## ANNOUNCEMENT OF EXAMINATIONS

Examinations are held each autumn by The Royal College of Physicians and Surgeons of Canada. Fellowship examinations are conducted in Internal Medicine and in General Surgery with modifications of these Fellowship examinations for certain specialties. Certification examinations are conducted in the approved medical and surgical specialties. The closing date for receipt of applications for the 1970 examinations was March 31. Applications for the 1971 examinations will be accepted between January 1 and March 31, 1971.

Prospective candidates who would like to obtain a preliminary assessment of their past and proposed training in preparation for the examinations of this College may apply for such an assessment at any time of the year.

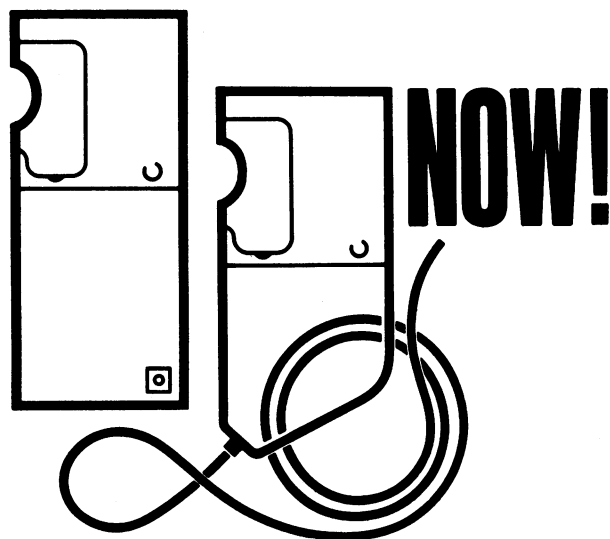
The following material may be obtained from the College headquarters:

- Regulations and Requirements of Graduate Training relating to the Examinations. Applicants should indicate whether they desire copies of the Medical or Surgical regulations.
- List of Canadian hospitals approved by the College for postgraduate training.
- Application forms for preliminary assessment of past and proposed training.
- Application forms for the examinations — Fellowship and Certification.

Address all communications to:  
The Secretary

**The Royal College of Physicians  
and Surgeons of Canada**

74 Stanley Avenue, Ottawa 2, Canada



## a complete **U-BAG®** system for infant urine collection

U-Bags are available for 24-hour full-volume specimens as well as for regular specimens. Two sizes permit a perfect fit on pediatric or tiny newborn contours, and the same bag fits boy or girl.



**HOLLISTER**

HOLLISTER LIMITED • 160 BAY STREET, TORONTO 116, ONTARIO