

Kinetics of Gastric Response in Chickens to Graded Electrical Vagal Stimulation¹ (37952)

RENÉ G. GIBSON, HARRY W. COLVIN, JR.,² AND B. I. HIRSCHOWITZ

*Division of Gastroenterology, Department of Medicine,
University of Alabama in Birmingham, Birmingham, Alabama 35294*

The role of the vagus in the control of gastric secretion has been studied by indirect methods such as insulin hypoglycemia or the use of glucose analogs such as 2-deoxy-D-glucose, neither of which have given clear answers as to whether the vagus in the chicken has a clear effect on gastric secretion (1, 2).

No data are available as to the effects of direct stimulation of the vagus nerve on gastric secretions. This study describes the kinetic evaluation of gastric secretion induced by direct electrical vagal stimulation, and shows that the stomach will respond in a dose-responsive fashion to such a vagal stimulus.

Materials and Methods. Four White Leghorn chickens, fasted for 24 hr, were anesthetized with percutaneous pentobarbital. The thoracic and abdominal cavities were exposed via a midventral incision and blunt dissection of the muscles away from the keel of the sternum. Unidirectional ventilation was established after rupturing the air sacs (3). A 4-cm-long polyethylene cannula of 6-mm diam with a 1-cm flange was inserted through a 1/4-in. incision anteriorly into the posterior margin of the proventriculus and anchored via a ligature. The anterior portion of the proventriculus was cannulated by inserting a 25-cm-long polyethylene cannula of 3-mm diam,

equipped with a syringe adapter, into the esophagus posterior to the crop and threading it into the anterior portion of the proventriculus. Gastric secretions were collected via a modified lavage technique (4) and volume recorded to the nearest 0.1 ml. Gastric secretions were collected in 30-min intervals and aliquots removed for titration with 0.01 N NaOH to pH 7. Pepsin output was determined by a modification of the hemoglobin technique (5). Experiments were not started until the basal rate of secretion had declined to below 0.1 mEq H⁺/15 min. In this preparation basal secretion under anesthesia was generally between 0 and 0.1 mEq H⁺/30 min.

The left cervical vagus was exposed in the neck of each fowl and a 4-cm portion dissected free. The nerve was cut and the distal portion of the nerve was placed across bipolar silver stimulating electrodes connected to a Grass S-5 rectangular wave stimulator. Beginning from an initial level of 5 V, the intensity of stimulation was increased by 5 V every 30 min until the secretory threshold was achieved. The birds were stimulated for only 30 sec/5 min in order to avoid excessive vagal depression of heart rate and blood pressure. Kinetic calculations were made by the method of Wilkinson (6).

Results. The onset of secretion occurred very rapidly (within 5 min) once threshold voltage was attained. The threshold for secretion was found to be 20 V, 10 pulses/sec, 1 msec duration, stimulating for 30 sec during each 5-min interval. Only the voltage was then increased every 30 min until a maximal intensity of 50 V was reached. Attempts to stimulate above 50 V were un-

¹ This work was supported by Training Grant in Physiology, GM01934, University of California, Davis, CA.

² Department of Animal Physiology, University of California, Davis, CA.

successful, apparently due to nerve destruction. The H^+ and pepsin outputs in response to vagal stimulation were found to be log sigmoid with an observed peak at 50 V (Fig. 1a,b). Linear transformation of this data was shown to yield straight lines (Fig. 1c,d). These results are given in Table I.

Discussion. Gastric secretion in the domestic fowl was found to be highly responsive to direct electrical stimulation of the vagi. The high electrical threshold of gastric secretion in response to vagal stimulation

can be attributed to the small diameter of the vagal fibers (7). The maximal output of acid in response to vagal stimulation was found to compare favorably with maximal cholinergic stimulation (Table I) (8), while pepsin outputs were found to exceed previously described levels in response to both urecholine and 2-deoxy-D-glucose stimulation (1, 8). Though previously suggested in other species by indirect vagal stimulation (9, 10) that the stomach responds in a graded fashion to vagal stimulation, this is

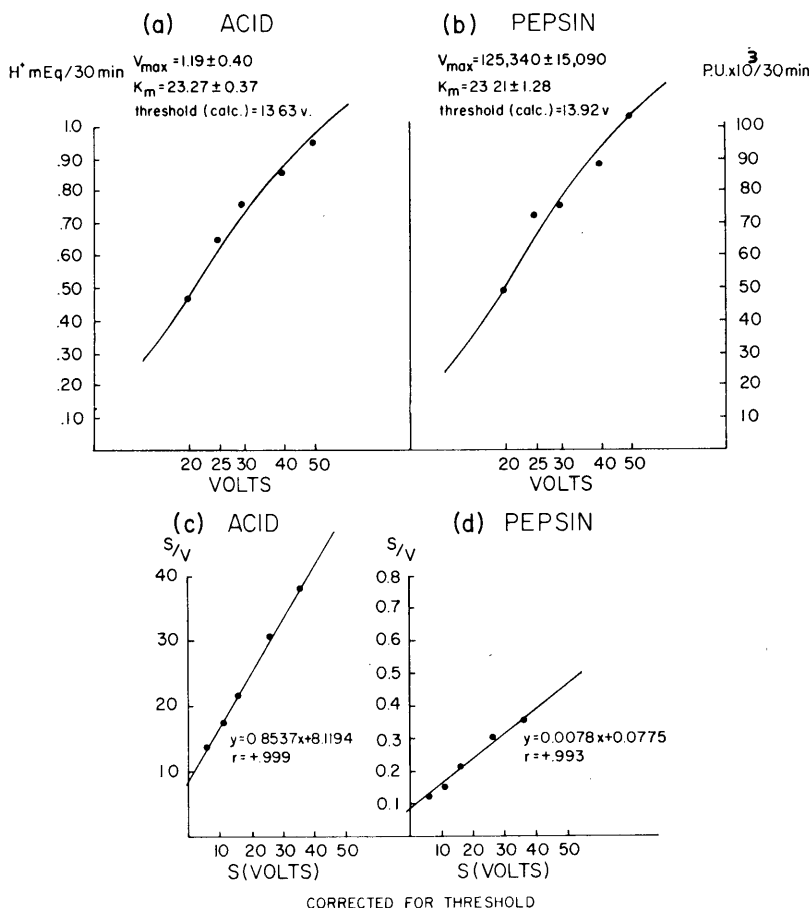


FIG. 1. (a) Dose-responsive secretion of H^+ in response to 30-min step increases in stimulation intensity. Each point is the mean of four experiments.

(b) Pepsin outputs for the same experiments.

(c) Linear transformation of data in (a) calculated by the linear transformation $(S - T)/V = a(S - T) + b$, where S = strength of current (volts), V = response, and T = calculated threshold of current. V_{max} values are for H^+ and pepsin output per 30 min, respectively, and K_m values are in volts.

(d) Linear transformation of data in (b).

TABLE I. Comparative Gastric Secretion in the Domestic Fowl in Response to Various Stimuli.

	H ⁺			Pepsin		
	Threshold	K _m	V _{max} (mEq/30 min)	Threshold	K _m	V _{max} (P.U./30 min)
Hist. (11)	—	97 µg/kg·hr	1.37	—	—	19,337 (obs. max.)
Pentag. (11)	—	61 µg/kg·hr	1.66	—	—	28,349 (obs. max.)
Urech. (8)	—	172 µg/kg·hr	1.26	—	81 µg/kg	26,170
(this study)	13.6 V	23.3 volts	1.19	13.9 V	23.21 V	125,340

the first direct demonstration in any species that the gastric response to the vagus is dose-responsive and not an all-or-none phenomenon.

Thus, gastric secretion of acid and pepsin in the domestic fowl appears to be under direct vagal control and is obviously dose-responsive.

Summary. The left cervical vagi of four domestic fowl, under pentobarbital anesthesia, were subjected to direct electrical stimulation. The stimulation parameters used were 5, 10, 15, 20, 25, 30, 40, and 50 V in successive 30-min steps, with the frequency and duration maintained at 10 pulses/sec and 1 msec, respectively.

By kinetic analysis, a threshold of 13.6 V was found for H⁺ secretion and 13.9 V for pepsin secretion. Linear transformations of the data produced good linearity ($r = +.999$ and $+.993$) for acid and pepsin, respectively. The levels of secretion produced by vagal stimulation exceeded previously reported outputs for cholinergic stimulation, and it was shown that the gastric response

to direct electrical stimulation of the vagus is dose-dependent and not all-or-none.

1. Burhol, P. G., and Hirschowitz, B. I., *Scand. J. Gastroenterol.* 6, Suppl. 11, 35 (1971).
2. Long, J. G., *Amer. J. Physiol.* 212, 1303 (1967).
3. Fedde, M. R., and Burger, R. E., *Poultry Sci.* 41, 679 (1962).
4. Borella, L. E., and Herr, F., *Gastroenterology* 61, 345 (1971).
5. Bucher, G. R., Grossman, M. I., and Ivy, A. C., *Gastroenterology* 5, 501 (1945).
6. Wilkinson, G. N., *Biochem. J.* 80, 324 (1961).
7. Dahl, N. A., Samson, F. E., and Balfour, W. M., *Amer. J. Physiol.* 206, 818 (1964).
8. Burhol, P. G., and Hirschowitz, B. I., *Scand. J. Gastroenterol.* 6, Suppl. 11, 25 (1971).
9. Hirschowitz, B. I., and Sachs, G., *Amer. J. Physiol.* 209, 452 (1965).
10. Spencer, J., and Grossman, M. I., *Gut* 12, 891 (1971).
11. Burhol, P. G., and Hirschowitz, B. I., *Gastroenterology* 56, 1141 (1969).

Received Oct. 31, 1973. P.S.E.B.M., 1974, Vol. 145.