Antral Motility in Patients with Gastric Ulcer

J. MARSHALL GARRETT, M.D., W. H. J. SUMMERSKILL, M.D.,
and CHARLES F. CODE, M.D.

GASTRIC HYPOMOTILITY in patients with gastric ulcer was first inferred from the roentgenologic observations of delay in the propulsion of opaque media.[1–4] Dragstedt and associates[5–7] have suggested that delay in gastric emptying may produce excessive release of gastrin, either from distention or from increased peristalsis in the antrum. By increasing secretion of acid, such a mechanism could contribute to ulceration.

We have made, therefore, quantitative determinations of antral gastric motility under basal circumstances in patients with chronic gastric ulcer and in healthy persons. When decreased propulsive motility was found in patients with gastric ulcer, the response of the antrum to distention was tested in 2 similar groups of individuals.

MATERIAL AND METHODS

Ten healthy persons (6 men and 4 women) volunteered as controls. After thorough examinations, none was found to have evidence of gastrointestinal disorder. Quantitative estimates of antral motility under basal conditions were made in all 10 (mean age, 29 years; range, 22–52 years). Antral distention was studied in 3 of the men and 2 of the women (mean age, 30 years).

Nineteen patients with benign, chronic gastric ulcer under treatment in the hospital were studied. The diagnosis of ulcer was made on clinical grounds and confirmed radiologically; malignancy was excluded by cytologic examination and, when indicated, by endoscopy or surgery, as well as by the subsequent clinical course. Thirteen of the 19 patients (8 men and 5 women; mean age, 60 years; range, 33–80 years) underwent the 2-hr. basal test. Antral motility following distention was studied in the 6 other patients with gastric ulcer; all were men (average, 55 years; range, 43–65 years). Two patients experienced pain of an ulcer type in the 24 hr. before the studies; the majority had been free of symptoms for at least 2 days.

Seven of the 13 patients having basal studies had ulcers located on the lesser curve; 3 had prepyloric ulcers; 2 had ulcers on the greater curve; and 1 had an ulcer on the posterior wall. In 10 patients, the ulcer was located at or below

From the Gastrointestinal Research Unit and the Departments of Physiology and Medicine, Mayo Clinic and Mayo Foundation, Rochester, Minn.

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the angle of the stomach. In addition to a gastric ulcer, the roentgenologist observed duodenal scarring in 4 patients; 1, later undergoing operation, had no evidence of duodenal ulcer. There was no difference in the motility patterns of patients with and without duodenal deformity. In studies of antral distention, ulcers were located on the lesser curve (5 patients) or on the greater curve (1 patient). One of these patients also had radiologic evidence of duodenal scarring.

PROCEDURES

Tests were performed after subjects had fasted 8–12 hr.; medications had been stopped the previous evening. Antral motility was recorded photokymographically for 2 hr. in the basal study by a method previously reported.[8] A small Sawyer balloon (3 × 5 cm.) was connected by a Sawyer gastric tube to a closed water-air reservoir. Pressure changes in the system were recorded by a strain-gauge transducer (Statham P23De*). The balloon was placed in the antrum and its position checked by cinefluoroscopy. Five milliliters of a radiopaque substance (Gastrografin†) in 20 ml. of water was slowly injected into the balloon under 15 cm. of water pressure.[8] The 25 ml. filled but did not distend the balloon. Observations were made with the subjects supine on a cinefluoroscopy table to allow checking the location of the balloon. Respirations were recorded by a belt pneumograph.

A latex balloon, connected by a polyethylene tube to a pressure-recording strain gauge, was used in the distention tests. The balloon was constructed so that its length was the same as that of the Sawyer balloon, but when the latex balloon was distended to a volume of 125 ml., its diameter was twice as great. The pressure within the balloon was then about 20 cm. of water. Tests with the latex balloon also lasted 2 hr., after it was positioned in the antrum. A control record of 30 min., while the balloon contained 25 ml. of air, was followed by a second 30-min. period when the volume was increased to 125 ml. This sequence was repeated during the second hour. During distention, antral contractions were recorded as superimpositions on the increased pressure within the balloon.

Cineradiography disclosed that the Sawyer balloon containing 25 ml. usually filled the distal portion of the antrum, but when the latex balloon contained 25 ml., only part of its circumference was in contact with the antral wall. Consequently, antral contractions seen in cineradiograms did not always produce changes of pressure in the flaccid latex balloon, and therefore the motility records for these periods were not analyzed. When the latex balloon contained 125 ml., it produced a spherical distention of the antrum (Fig. 1) and reliably recorded contractions seen in the cineroentgenograms.

*Statham Instruments, Inc., Los Angeles, Calif.
†E. R. Squibb & Sons, New York, N. Y.

The basal and the maximal acid output of the stomach were measured in all patients with gastric ulcer by the augmented histamine test of Kay,[9] as described by Card and Sircus.[10]

Analysis of Motility Records

The classification suggested by Templeton and Lawson[11] and later modified by others[12, 13] was used. Three types of waves with the following general characteristics were identified:[13] Type I—pressure of 5 cm. of water or less and duration of 18–20 sec.; Type II—pressure of more than 5 cm. of water and duration of 12–25 sec.; and Type III—base-line pressure change producing pressures of 1–10 cm. lasting 2–5 min., upon which are superimposed Type I or Type II waves.

Portions of the record disfigured by movements of the body, coughing, and straining were excluded. The duration (in seconds) and amplitude (in centimeters) of water of each wave were measured. Type I and Type II waves were classified as rhythmic when 4 waves or more occurred in regular sequence and as nonrhythmic when the waves occurred irregularly. The frequency per minute of rhythmic waves was determined. The percentage of time that each wave was present was calculated for each 30-min. period; a mean of 27.5 min. (range, 25.2–28.7 min.) of analyzable record was obtained. For the 2-hr. test,

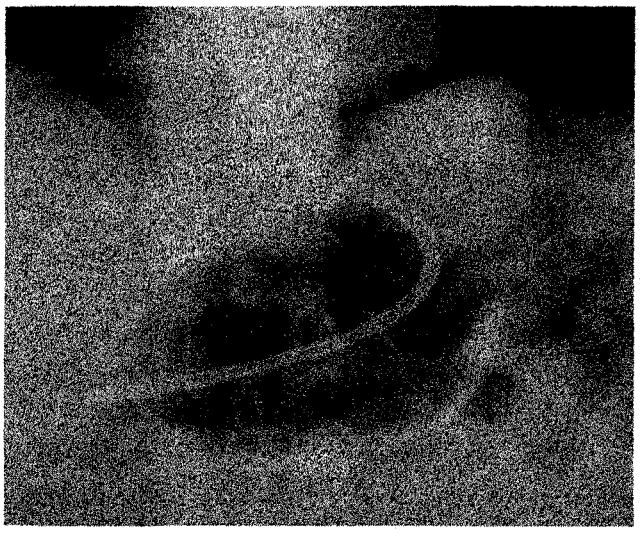

Fig. 1. Antrum distended by latex balloon containing 125 ml. of air in patient with gastric ulcer.

the duration of the analyzable records was 111.7 min. for the control and 110.4 for the ulcer group. In addition, total activities were calculated for the 2 hr. of the basal test and for the combined 2 periods of antral distention. Only in 11 of the 13 patients was the full 2-hr. basal test analyzable.

RESULTS

Basal Antral Motility

During the 2-hr. period of the basal test, fewer Type II contractions occurred in patients with gastric ulcer. The difference was due to a reduced incidence of rhythmic Type II waves. Nonrhythmic Type II activity was the same in the control and patient groups (Tables 1 and 2). In both groups, nonrhythmic Type II waves occurred more often than did rhythmic ones (Fig. 2). Nine of 13 patients with gastric ulcer but only 3 of the 10 healthy volunteers had no rhythmic Type II activity in more than one 30-min. period.

The most significant differences in percentage of rhythmic and total Type II activity were present in the first and second 30-min. periods, because the percentage of activity of the rhythmic Type II contractions in healthy persons decreased during succeeding 30-min. periods. By contrast, Type II activity in patients with gastric ulcer did not change (Table 2).

Mean frequencies of rhythmic Type II waves were similar in health and in gastric ulcer patients, being 3.21 and 3.05/min., respectively. Neither the amplitude nor the duration of Type II waves differed in the 2 groups. The number, amplitude, and duration of Type I and Type III waves were not significantly different in control individuals and ulcer patients (Table 1). Because of similarities of Type I waves (rhythmic and nonrhythmic waves) in relation to the factors studied and because of their lesser role in gastric emptying, only the total activity has been reported (Table 1). Type III activity occurred most frequently in the first 30 min. and then gradually decreased (Table 1).

After treatment, tests were performed in 3 patients who were free of symptoms and were without residual evidence of gastric ulcer by radiography. In each patient, the antral motility pattern was normal, having previously shown the changes associated with gastric ulcer (Fig. 3). With the ulcer present, the mean total duration of rhythmic Type II waves was 6.9 min. for the 2-hr. basal test (range, 1.8–10.3 min.). After ulcer healing, a mean total duration of 37.0 min. (range, 11.0–69.6) of rhythmic Type II waves was recorded. No change occurred in nonrhythmic Type II waves.

There was no difference in antral motility patterns in relation to the age of the patient and location or size of the gastric ulcer. Three patients experienced abdominal discomfort of an ulcer type during the test, but no change in antral motility was found at these times. No difference in motility patterns was found between patients with radiologic deformity of the duodenum and those without it—nor were the results of gastric analysis significantly different in these groups. In all patients with gastric ulcer, mean basal acid output was 1.8 mEq./hr. (range, 0.2–6.0); after the augmented dose of histamine, mean acid output was 19.5 mEq./hr. (range, 3.8–46.7). Acid secretion in the 4 patients with radiologic evidence of duodenal deformity was similar. Mean basal acid output was 0.9 mEq./hr. (range, 0.3–1.1), and mean output after histamine was 17.4 mEq./ hr. (range, 13.6–23.2).

TABLE 1. ANTRAL MOTILITY IN CONTROLS AND GASTRIC ULCER PATIENTS: TYPES OF CONTRACTION*

	30-min. periods								*Total, mean and S.E. (2 hr.)*	
	0–30		*30–60*		*60–90*		*90–120*			
	Control	*Gastric ulcer*	*Control*	*Gastric ulcer*	*Control*	*Gastric ulcer*	*Control*	*Gastric ulcer*	*Control*	*Gastric ulcer†*
TYPE I (TOTAL)										
Individuals (No.)	10	12	10	13	10	12	10	11	10	11
Waves (No.)	4.6	16.2	4.3	18.5	7.6	14.7	8.4	11.3	24.9 7.34	46.5 10.41
Amplitude (cm. H_2O)	4.1	3.2	3.8	3.0	3.8	3.0	3.5	3.3	3.8 1.54	3.2 1.14
Duration (sec.)	13.8	14.4	13.6	14.3	14.1	15.4	13.6	13.8	13.8 1.64	14.3 5.17
TYPE II										
Individuals (No.)	10	12	10	13	10	12	10	11	10	11
Nonrhythmic waves										
No.	11.5	14.9	14.4	10.6	10.3	13.5	11.7	11.8	50.7 6.29	42.5 6.29
Amplitude (cm. H_2O)	33.3	26.5	40.5	27.2	46.6	30.4	34.4	35.6	41.2 14.3	31.6 11.2
Duration (sec.)	17.8	26.7	19.6	25.1	22.2	24.3	18.0	24.5	19.9 6.6	24.9 7.9
Rhythmic waves										
No.	44.8	10.2	30.7	6.1	21.3	8.5	16.1	5.9	112.9 22.84	25.8 13.21
Amplitude (cm. H_2O)	37.5	43.5	42.2	22.2	33.4	17.8	23.0	25.2	40.5 17.25	21.15 12.35
Duration (sec.)	15.5	19.6	19.3	17.1	19.2	18.6	17.1	18.9	17.86 6.62	18.63 10.61

	TYPE III									
Individuals (No.)	10	12	10	13	10	12	10	11	10	11
Waves (No.)	4.7	6.1	4.9	2.0	3.8	3.6	1.9	2.3	15.3	11.6
									3.60	3.08
Amplitude (cm. H_2O)	4.3	3.7	4.9	4.0	4.2	3.7	4.1	6.0	4.7	5.4
									2.15	2.49
Duration (sec.)	47.8	61.5	41.6	49.7	45.9	51.1	56.1	60.8	52.4	58.1
									19.18	23.45

*Mean values by 30-min. periods.
†Only 11 gastric ulcer patients had complete 2-hr. test.

TABLE 2. ANTRAL MOTILITY: TYPE II CONTRACTIONS IN CONTROLS AND PATIENTS WITH GASTRIC ULCER

	30-min. periods								*Combined 2-hr. activity*	
	1		*2*		*3*		*4*			
	Control	*Gastric ulcer*	*Control*	*Gastric ulcer*	*Control*	*Gastric ulcer*	*Control*	*Gastric ulcer*	*Control*	*Gastric ulcer*
	TYPE II ACTIVITY (TIME IN MINUTES)									
Individuals (No.)	10	12	10	13	10	12	10	11	10	11
Mean (min.)	16.16	8.84	14.86	4.76	10.36	6.95	7.92	5.76	49.31	26.67
	(56.5) *	(32.4)	(51.7)	(17.1)	(37.0)	(39.7)	(30.3)	(22.8)	(44.1)	(24.2)
S.E.	1.85	1.49	1.53	1.28	2.22	1.21	1.29	1.32	5.25	3.03
P value	<0.01		<0.001		>0.10		>0.20		<0.001	
	RHYTHMIC ACTIVITY (TIME IN MINUTES)									
Individuals (No.)	10	12	10	13	10	12	10	11	10	11
Mean (min.)	12.84	2.76	9.91	1.35	6.61	2.23	4.44	1.58	33.81	8.45
	(44.9)	(10.1)	(34.4)	(6.7)	(23.4)	(8.1)	(17.0)	(6.3)	(30.3)	(7.3)
S.E.	2.31	0.92	2.76	1.06	2.24	1.26	1.51	0.98	7.01	4.04
P value	<0.001		<0.005		>0.05		>0.05		<0.005	

*Numbers in parentheses indicate percentage activity of analyzable record.

Responses to Antral Distention

During antral distention, Type II activity was the same in healthy persons as in patients with gastric ulcer (Fig. 4 and Table 3). Type II activity was comparable during both periods of distention (Table 3), and the duration and amplitude of rhythmic and nonrhythmic Type II waves were similar in both groups. Type II activity during antral distention in healthy individuals (Table 3) was similar to that during the comparable 30-min. periods (second and fourth) of the basal motility test (Table 2). By contrast, patients with gastric ulcer showed significantly greater Type II activity during antral distention than in their corresponding 30-min. basal period ($p < 0.01$).

Type I and Type III waves were not significantly altered by antral disten-

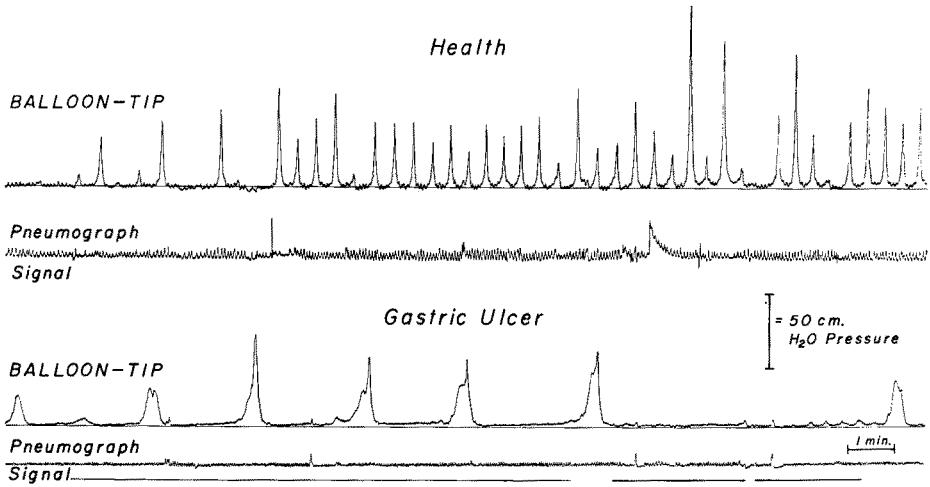

Fig. 2. Antral motility in health and in gastric ulcer.

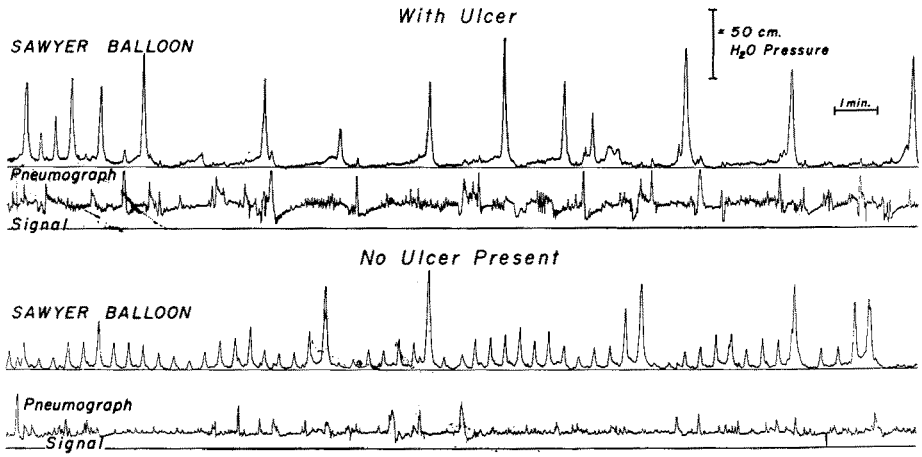

Fig. 3. Changes in antral motility after healing of gastric ulcer.

TABLE 3. ANTRAL MOTILITY AFTER BALLOON DISTENTION: TYPE II CONTRACTIONS IN CONTROLS AND PATIENTS WITH GASTRIC ULCER

	30-min. periods					
	Distention Period 1		*Distention Period 2*		*Combined 1 hr. activity*	
	Control	*Gastric ulcer*	*Control*	*Gastric ulcer*	*Control*	*Gastric ulcer*
TYPE II ACTIVITY (MINUTES)						
Individuals (No.)	5	6	5	6	5	6
Mean	14.47	11.78	16.07	11.06	30.54	23.84
	(51.0) *	(41.6)	(57.4)	(44.2)	(54.2)	(44.7)
S.E.	2.26	0.19	1.96	2.92	2.97	4.19
P value	>0.30		>0.10		>0.10	
RHYTHMIC TYPE II ACTIVITY (MINUTES)						
Individuals (No.)	5	6	5	6	5	6
Mean	9.07	4.87	9.18	7.07	18.26	11.94
	(31.9)	(17.2)	(32.8)	(28.0)	(32.4)	(22.3)
S.E.	2.58	1.57	1.84	3.14	4.00	4.23
P value	>0.10		>0.40		>0.30	

*Numbers in parentheses indicate percentage activity of analyzable record.

tion, either in health or in patients with ulcer. Four of 5 healthy persons were aware of abdominal discomfort immediately after antral distention, but none with ulcer experienced discomfort. No change in motility pattern was found at such times.

DISCUSSION

In health, the majority of Type II antral waves are propulsive and constitute the most important gastric contractions with this function.[14, 15] The significant reduction of rhythmic Type II activity found in patients with gastric ulcer

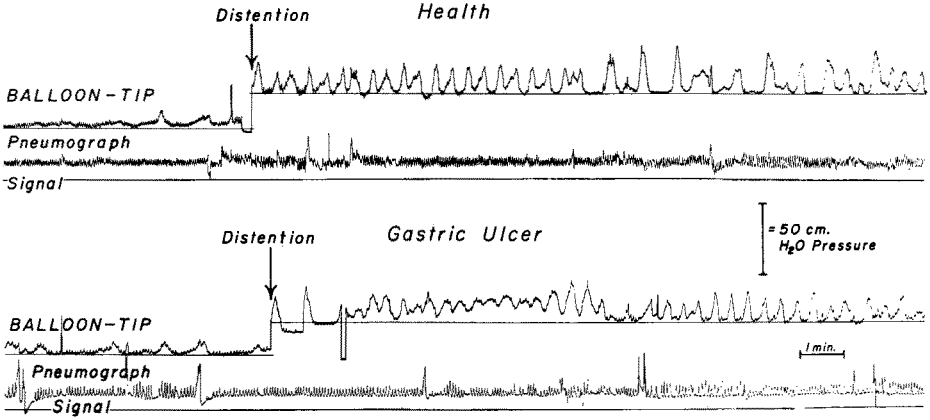

Fig. 4. Effect of distention on antral motility in health and in gastric ulcer.

accords wih the impairment of gastric emptying reported by radiologists.[2–4] In addition, Brauch[16] found, by kymography, altered gastric motility in patients with gastric ulcer but attributed the change to "arrhythmia gastrica," emphasizing the prominence of nonrhythmic Type II contractions (poikiloperistalsis) rather than the reduction of rhythmic Type II activity revealed by this study.

Although reduction of antral motility under basal circumstances might permit greater accumulation of gastric secretion in the stomach, no evidence was forthcoming to support the theory that, with gastric ulcer, a primary disorder of motility permits an abnormal response to distention of the antrum, with a consequent increase in acid secretion which may contribute to ulceration.[5, 6] Antral motility following distention was unimpaired in patients with gastric ulcer and, in addition, normal motility patterns were obtained after the ulcer had healed. These findings indicate a secondary effect of the ulcer on motility, perhaps an interruption between action potentials and the contractile mechanism of antral smooth muscle.

Reduction of antral motility in patients with ulcer was significant only during the initial hour of the study. Since intubation is believed normally to increase gastric motility,[17] loss of such a response to a nondistending stimulus may represent an important defect in antral motor function with gastric ulcer. However, although the decrease in propulsive waves was significant only in the initial hour, when fasting, reports of retention of barium for as long as 24 hr. in patients with gastric ulcer[1–4] imply the possibility of a more prolonged impairment of motility. Barium or food may not distend the antrum to the degree of the balloon used in our studies, but the normal response to antral distention by the balloon mechanism in patients with gastric ulcer indicates that local mechanisms remain capable of compensating for the motility disorder.

Percentage of Type II activity in healthy individuals in this study was higher than that recorded by Hightower and Code[13] but less than that found by Smith and Code.[18] As we did, Smith and Code also found a reduction in the number of all wave types with time in healthy individuals. The greater incidence of Type III activity in health than was found in previous studies[13] probably reflects inclusion of base-line changes with superimposed nonrhythmic as well as rhythmic contractions in the analysis. Insofar as the function of Type III waves is attributable to the maintenance of tonus, our results failed to support the radiologic impressions of decreased tonus with gastric ulcer.[1] In addition, no characteristic alteration in any wave type was detected in our studies during periods of abdominal discomfort, although ulcer pain had been ascribed to changes in tone or motility.[19] Finally, it is relevant that our patients with gastric ulcer and duodenal deformity demonstrated neither the antral motility pattern[20] nor the gastric secretory changes[21] characteristic of duodenal ulcer, despite the frequency with which the latter is believed to be the original of the 2 lesions when both types of ulcer are found.[21]

SUMMARY

Quantitative analysis of antral motility in patients with gastric ulcer revealed a significant decrease in rhythmic propulsive Type II contractions. After healing of the ulcer, the motility patterns returned to normal. When the antrum was distended, the motor response in ulcer patients was similar to that of healthy volunteers.

Mayo Clinic
Rochester, Minn. 55901

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