Atraumatic Recording of Gastric Contractions in Conscious, Unrestrained Rats

ROLAND P. ROTH* and MARTIN F. TANSY▲

Abstract ☐ An atraumatic balloon technique is presented whereby gastric motor function is directly recorded from conscious, unrestrained rats continuously for as many as 5 days and intermittently for periods up to 2 weeks. Intragastric motility patterns resulting from these animals demonstrate good recording stability and are remarkably free of artifacts during their physiological and behavioral activities. The tracings during fasting most frequently showed periods of relative quiescence with occasional bursts of high amplitude contractions. After stimulation with either food or water, digestive contractions were obtained. The inherent limitation to the usefulness of this technique is anatomical inasmuch as it is less applicable for use in very small animals.

Keyphrases ☐ Gastric motility—atraumatic balloon technique, conscious, unrestrained rats ☐ Digestive and interdigestive contractions—atraumatic balloon technique, unrestrained rats ☐ Balloon technique—recording of gastric contractions in conscious, unrestrained rats

The pylorus-ligated rat (1) has been extensively employed as a means of studying gastric acid secretion. The consistently repetitive nature of the interdigestive gastric contractions in the rat makes this animal equally valuable for the study of gastric motility. Unfortunately, at the present time there is no widely accepted method of obtaining chronic physical measurements of gastric motor activity in the unanesthetized rat.

Figure 1—*Photograph displaying gastric motility recording apparatus. From left to right: intragastric balloon with polyethylene inflation tube, fluid swivel assembly, and spring-guide and harness.*

The closest approach to a viable chronic preparation appears to be the surgical insertion of a fluid-filled balloon according to a technique developed by Morrison *et al.* (2). Despite its claimed advantages, their technique suffers from the obvious drawbacks of operative trauma

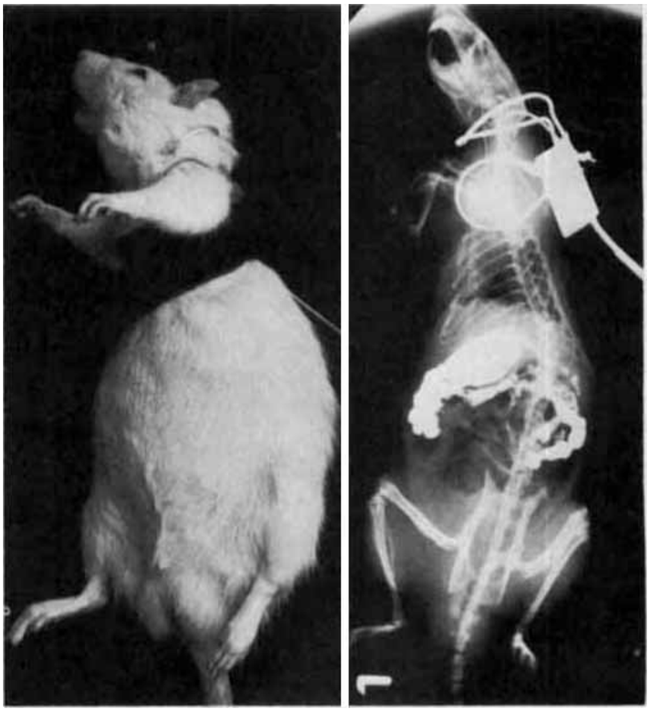

Figure 2—*A composite photograph and radiograph of a rat with the entire catheter and guide assembly in place.*

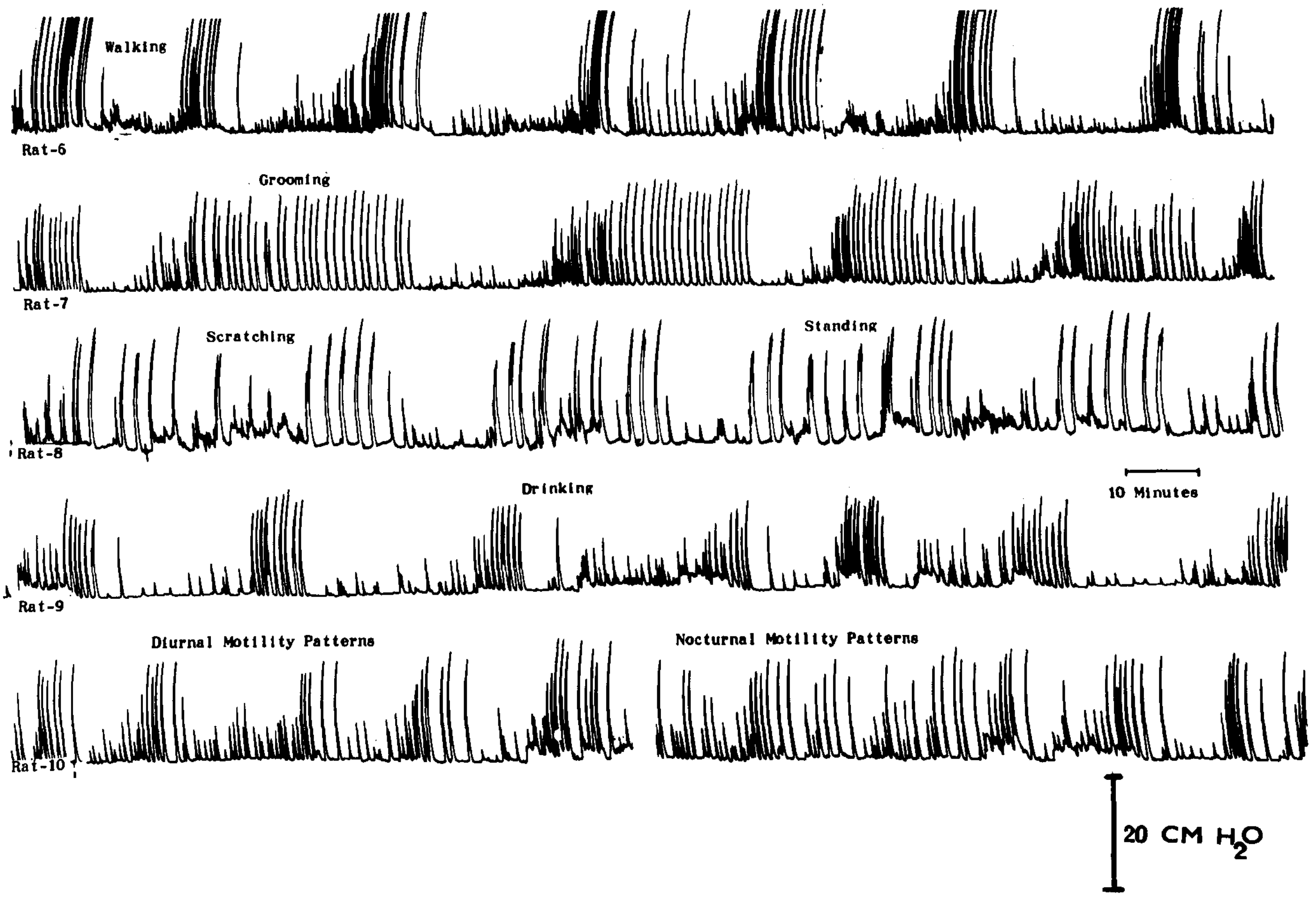

Figure 3—*Gastric motility patterns. Individual patterns of burst activity of five rats in the fasted state, showing general lack of effects that were produced by various spontaneous activities.*

and surgical damage to the intramural nerve plexus. Furthermore, these preparations do not remain viable for extended periods of time. This report describes a convenient, atraumatic, and relatively sensitive method of chronically measuring pressure changes associated with gastric motor activities in the rat.

EXPERIMENTAL

Apparatus—An intragastric balloon for rats fashioned from the inflatable section of a Foley catheter was described by Epstein (3). The round tip of the catheter is glued to the end of the balloon to make a smooth blunt surface which will slide down the esophagus in accordance with the technique of Hoebel (4).

Procedure—The balloon proper is attached to polyethylene (PE-10) tubing [0.03 cm. (0.011 in.) in internal diameter and 0.06 cm. (0.024 in.) in external diameter] which has been threaded up the rat's nostril and out of the mouth. After being attached, the balloon is then eased down the rat's esophagus by means of a "pusher" aided by swallowing, the rat being under very light pentobarbital anesthesia. When the balloon is in the stomach, the "pusher" is removed. Four milliliters of water is then introduced into the balloon, and the polyethylene tubing is clamped and attached by the connecting system to the recorder. The balloon volume is left constant for all experiments. This method eliminates the need for repetitive traumatic oral intubation and the rats, once prepared, receive minimal handling. The rats do not require further sedation or restraint.

The fluid-filled tube is then passed to the top of the head by tunneling under the skin from the nostril and is led inside of a flexible spring-guide to a fluid-tight swivel. The spring-guide prevents the fluid-filled tube from kinking, and it is supported by a harness which is worn externally by the rat (Fig. 1). The harness, a commercially available item[1], was modified by the addition of three wire loops encased in polyethylene tubing. The head and forelimbs were thrust through their respective loops to prevent rotation of the harnesss about the long axis of the animal. The output of the fluid swivel was fed to a polygraph[2] *via* a pressure transducer[3]. Figure 2 shows the entire harness and catheter assembly mounted on and within a rat.

After recovery from the anesthesia, each animal was returned to its individual cage and allowed free run of the cage.

RESULTS AND DISCUSSION

Thirty male Sprague-Dawley rats, weighing no less than 200 g., were prepared with intragastric balloons according to the described procedure. Typical measured data for various continuous time periods are shown in Figs. 3–5. Short-term gastric motor activity patterns revealed both cyclical bouts of activity and random contractions (Fig. 3). Three general patterns of GI motor activity, as described by Jacoby *et al.* (5), were observed in this study. Basal activity consisted of low amplitude contractions with no prominent tonal changes; burst activity interrupting the basal pattern consisted of grouped high amplitude contractions which were usually superimposed on tone increases; and intermediate activity consisted of varying amplitude, ungrouped contractions often superimposed on low amplitude tone changes. As can be seen in Fig. 3, during the interdigestive state the predominant basal activity was interrupted by burst activity. No appreciable artifacts were seen during the periods when the rat was in the standing position, which includes walking in the cage. The recordings were also remarkably free of

[1] The cannular feedthrough swivels (model 1603) and cannular saddle (model 1602) were obtained from Lehigh Valley Electronics, Fogelsville, PA 18051

[2] Grass model 7.

[3] Statham P23AC.

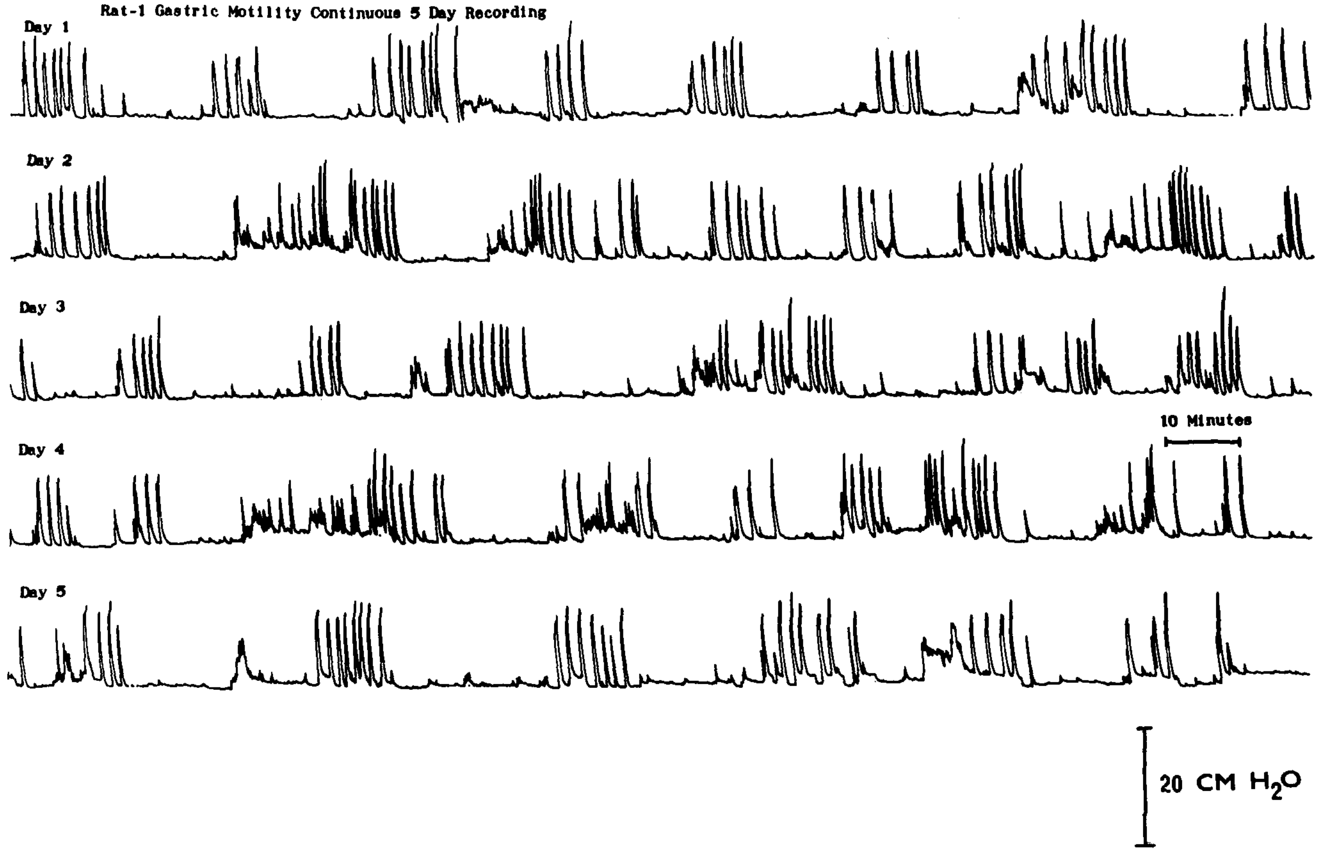

Figure 4—*Polygram sections showing burst and basal gastric motility in the same rat at selected intervals during a continuous 5-day recording.*

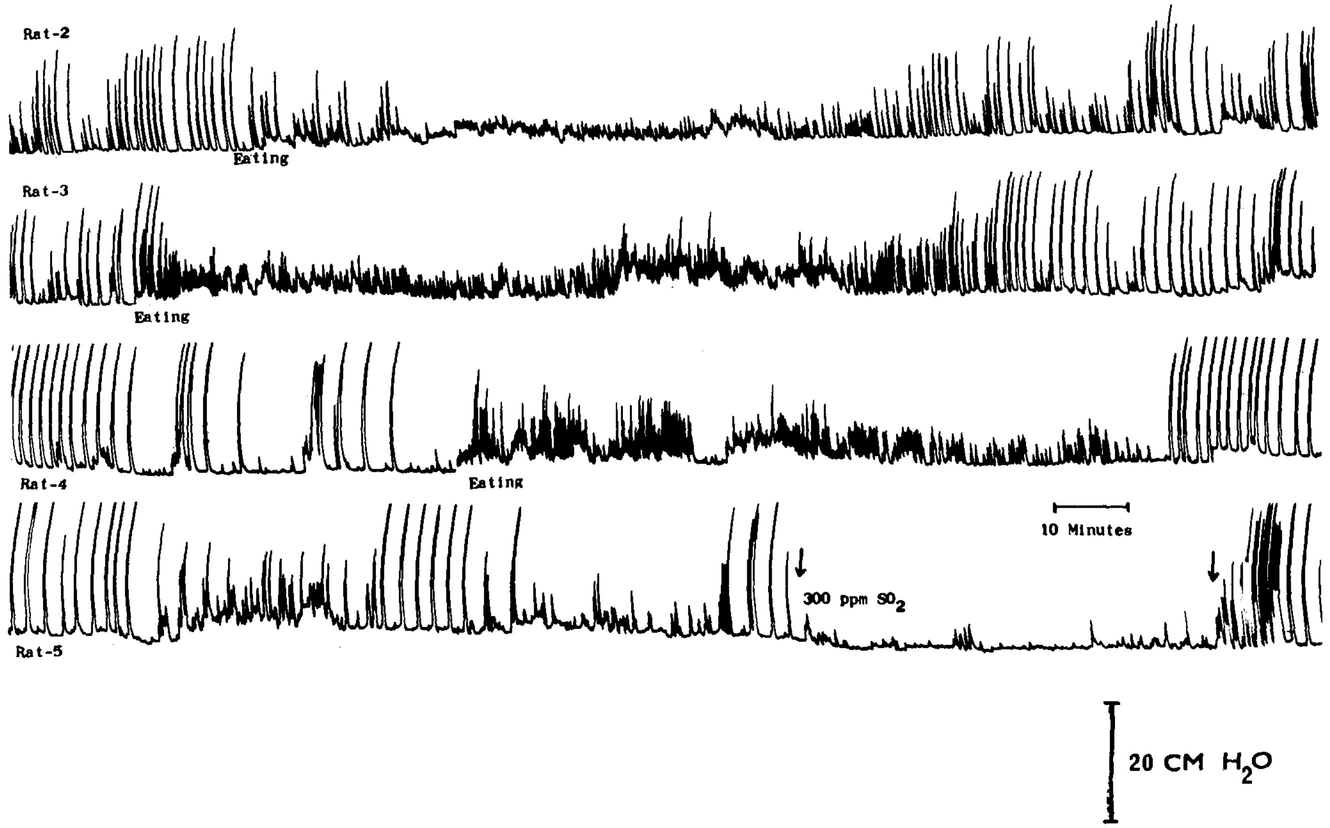

Figure 5—*Polygram sections showing the conversion of gastric motor activity from interdigestive to intermediate digestive patterns as a result of feeding three rats. Interdigestive motor patterns were converted to basal types when a high concentration of sulfur dioxide gas was administered to the fifth animal during the period indicated by arrows.*

artifact during periods of grooming and scratching. Figure 3 also shows samples of activity obtained in a rat during continuous recording over 24 hr. The long-term stability of the recording appears to be good.

Burst activity distribution varied among rats (Fig. 3) but was reproducible in each rat from day to day. For example, a rat that grouped burst activity in one continuous 10-min. episode with approximately 70 min. between bursts showed this type of pattern day after day in recordings made during the fasted state. Other rats spaced four episodes of burst activity, each of about 30-min. duration, among basal periods lasting about 10 min., and they did so every day. Figure 4 shows samples of interdigestive activity obtained in a rat during continuous recording over 5 days. Again the stability of the recordings was good. The recordings were remarkably free of excessive respiratory, cardiac, and behavioral artifacts.

In experiments other than those depicted, intermittent recordings were made for periods as long as 14 days. At the end of this time the animals and the measuring systems were in good condition and could have been utilized for a longer duration. Continuous observations of these experimental animals failed to reveal evidence of anorexia, weight loss, or unusual body movements. Autopsy of several rats after various intubation periods failed to show either ulceration, which could be interpreted as a reaction to restraint, or other evidence of trauma which might have been produced by the intubation procedure.

Figure 5 shows samples of gastric motor activities obtained in four rats during continuous recording over a 6-hr. period. In three of the rats, intermediate-type activity was the predominant type of gastric motility during the digestive state. This pattern sometimes occurred in the interdigestive state for a brief period prior to a burst. On feeding, burst activity immediately ceased in the stomach and then intermediate pattern activity began and persisted in the stomach for 1–2 hr. After ingestion of water (Fig. 3), intermediate-type activity was not as marked.

As reported earlier (6), a practical usefulness of this technique is revealed by the fact that a temporary reflex inhibition of existing gastric contractile activity is seen with atmospheric exposure to a high level of sulfur dioxide (Fig. 5). Weedon (7) reported the occurrence of gastric distension in mice and guinea pigs exposed to sulfur dioxide. This observation is noted only to indicate that this technique may have potential usefulness for the experimental determination of those changes in gastric motility patterns that are produced by the administration of various agents by means of aerosol inhalation or *via* other routes.

Earlier investigators (2) obtained results qualitatively similar to those obtained in this study; that is, their fasted-state recordings consisted of quiescence interrupted by periods of increased motor activity at irregular intervals. Our data and that of Morrison *et al.* (2) agree that the stronger contractions occur during the interdigestive state compared to the digestive state. Furthermore, the highly individualized gastric contractile patterns would suggest that each rat can and should serve as his own control.

The method described in this study has several advantages over those reported in the literature. First, the animals do not have to be permanently immobilized by an anesthetic or muscle relaxant which may modify or even mask the effect of a drug screening procedure. Second, because the stomach is entered through the esophagus, there are no stomach wounds to necrose or cause pain. It was unnecessary to interrupt gastric continuity, content flow, or intramural nerve or blood supply. Two other factors which are of considerable importance in recording gastric systolic and diastolic variations are:

1. The internal diameter of the Foley catheter is large enough to ensure that the response of the measurement system is adequate to register intragastric pressure events.
2. One can record for considerable periods of time without having to worry about the effects of gastric juices and peristaltic action on the balloons.

Finally, the factor of restraint is almost completely eliminated. The only restraint involved is in keeping the rat from wandering too far from the transducer and pulling on the catheter. In the methods reported to date, chronic balloon recording involves a considerable degree of restraint. It has been mentioned that the animals get used to this kind of technique and that eventually the motility patterns observed represent those of the normal animal rather than one that is restrained. The fact remains, however, that the animals are still highly restrained whether thay get used to it or not. An added point in favor of our technique is that it is an easy preparation to maintain in that the animals are able to move normally and remain healthy with ordinary food and maintenance. The one drawback of this technique is that it cannot be readily performed in animals smaller than young adult rats because the size of the catheter is limiting. Nevertheless, this technique might be extended to other species for physiological and pharmacodynamic studies.

REFERENCES

(1) H. Shay, S. A. Komarov, S. S. Fels, D. Merance, M. Grüenstein, and H. Siplet, *Gastroenterology*, **5,** 43(1954).

(2) S. D. Morrison, J. L. Hsiang, H. E. Eckel, T. B. VanItallie, and J. Mayer, *Amer. J. Physiol.*, **193,** 4(1958).

(3) A. N. Epstein, *Science*, **131,** 497(1960).

(4) B. G. Hoebel, *J. Appl. Physiol.*, **22,** 189(1967).

(5) H. I. Jacoby, P. Bass, and D. R. Bennett, *ibid.*, **18,** 658(1963).

(6) M. F. Tansy and R. P. Roth, *Physiologist*, **13,** 296(1970).

(7) F. Weedon, *N. Y. State J. Med.*, **42,** 620(1942).

ACKNOWLEDGMENTS AND ADDRESSES

Received March 8, 1972, from *Temple University Schools of Dentistry, Pharmacy and Allied Health Professions, Department of Physiology and Biophysics, Philadelphia, PA 19140*

Accepted for publication May 2, 1972.

Abstracted in part from a thesis submitted by Roland P. Roth to Temple University in partial fulfillment of the Ph.D. degree requirements.

Supported by a National Institutes of Health Predoctoral Fellowship from the Division of Environmental Health Sciences.

* Present address: Department of Health, Education, and Welfare, Public Health Service, National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709

▲ To whom inquiries should be directed.