all the tubes to the duodenum, successful and unsuccessful.

We are able, I believe, to state that increasing the weight of the tip beyond 69 grains (Twiss Tube) does not hasten the intubation time. It remains to be determined if a metal weight helps at all in this respect, although these figures suggest that it does.

OTHER CLAIMS

These cannot be accurately determined, so that we are dealing merely with impressions. We believe that covering the metal tip with rubber is a desirable modification. Patients occasionally are worried by the possibility of the tip becoming detached with other tubes. A satisfactory volume of bile can be obtained with each of the tubes described—clogging has been infrequent. We believe that the greatest factor in causing trauma to the mucous membrane is suction, and it should be scrupulously avoided, except just enough to start the siphonage.

Tubes slipping out have not been a serious problem. On one occasion, during my internship, I saw a fatal hemorrhage from esophageal varices following the use of a metal tip—a blood clot was present on the tip when it was withdrawn. Although this is a very rare occurrence, its possibility should be remembered.

CONCLUSIONS

1. A successful intubation of the duodenum was accomplished in a two-hour period with any one of four tubes used, in about 90% of the attempts.
2. A lead weighted tip appears to hasten entrance into the duodenum. This, however, has not been determined beyond doubt.
3. Increasing the weight of the tip from 69 grains (Twiss Tube) to 150 grains (Moses Einhorn Tube 1938) does not appear to accelerate its passage, or increase the percentage of successes.

Note: I am grateful to Elsa Nussbaumer, R.N., for her technical assistance.

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A Method for the Continuous Recording of Gastric pH in Situ

II. Experimental Details

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P\textsc{revious} investigators have studied gastric acidity by means of the Pavlov pouch and also by the method of frequent aspirations. Samples of the specimens obtained by these methods were then titrated against 0.1 \textit{N} sodium hydroxide with phenolphthalein or Töpfer's reagents as indicators and the results were expressed in terms of free hydrochloric acid or total acid respectively.

With the advent of the glass electrode the gastric acidity has frequently been expressed in terms of pH units. In all such instances the measurements were performed on aspirated specimens. In order to obtain pH values of the gastric juice \textit{in situ} we have devised a glass electrode for direct use in the stomach (1).

Two modifications of the bulb form of the glass electrode of the silver-silver chloride type were found to be satisfactory for this purpose. One was blown from 2 mm. glass tubing and provided with a hard glass or rubber cylindrical jacket of 10 mm. diameter with an open end and perforated wall, to allow free circulation of the gastric contents around the glass electrode. The other was an unshielded bulb, 8-10 mm. in diameter, held away from the stomach wall by means of a small rubber balloon fixed around the neck of the electrode and inflated after introduction of the electrode into the stomach.

Employing either modification, the platinum lead of the electrode was joined to well-insulated flexible metal-sheathed multi-strand copper wire which was passed through a No. 18 fr. Levine tube, whose lower extremity was hermetically sealed to the electrode. (Diagram 1). For aspiration purposes, a second Levine tube with all openings closed with balloon rubber save that immediately opposite the electrode, was attached alongside the tube carrying the electrode and projecting 2-5 cms. to prevent contact of the electrode with the stomach wall. By means of a moist-

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ened thread passing through this aspirating tube contact was made with the reference electrode which was of the saline silver-silver chloride type. (Otherwise contact was made through the body by direct external contact of the reference electrode with the skin; it being necessary to compensate for extraneous potentials when using this method).

The leads from the stomach and reference electrodes were connected to a Beckman pH meter which in turn was connected to a recording potentiometer. The aspirating Levine tube was connected through a 3-way stopcock with a glass-ball trap and a rubber bulb which was compressed at regular intervals by a piston driven by a slowly rotating motor. (Diagram 1). This pumping system periodically withdrew and returned about 35 cc. of gastric contents and in this manner distilled water. The pH was determined and after return to the stomach was again measured in situ by the continuous recording instrument. After a satisfactory control run of 5-10 minutes, 1 gram of sodium bicarbonate in 100 cc. distilled water was introduced through the Levine tube and followed by 50 cc. of distilled water. Continuous recordings were made throughout the experiment with occasional interruption for withdrawals of gastric juice for comparative external determinations.

The instillation of alkali into the stomach caused an immediate rise in pH, followed by a gradual fall until the end point (neutralization point of added alkali) was reached when an abrupt fall in pH took place. (Fig. 1).

Diagram 1. Arrangement for the determination of gastric pH in situ. A—Glass electrode lead to pH meter; B—Reference electrode; C—Mechanical pump; D—Glass reservoir; E—Glass electrode and aspirating tube; F—Detail of glass electrode and aspirating tube.

continuously bathed the glass electrode with the agitated stomach fluid.

The following experiments were performed on dogs anesthetized with morphine sulfate (8 mgm. per kgm. by subcutaneous injection) and chloralose (70 mgm. per kgm. by intravenous injection). The anesthetized dog was placed in supine position at an angle of 45 degrees. The double Levine tube was introduced until it reached the greater curvature of the stomach and was then withdrawn until it was just above this depth. The actual position was determined by fluoroscopic examination.

A pH reading was made with the stomach electrode and this value was checked against the pH of an aspirated specimen measured with an external glass electrode instrument. The residual total gastric content was then aspirated, and diluted to 100 cc. with

Fig. 1. Effect of 1 gm. NaHCO₃ on gastric pH of a dog with hypersecretion induced by a continuous histamine injection (0.5 cc. per hour). S = pH determined from the tracing using the stomach electrode. V = pH of corresponding aspirated specimen using a standard electrode.

**DISCUSSION**

This work has been carried out over a period of eighteen months. The many irregular results which were first obtained were found to be due to technical faults which were gradually eliminated. In the early experiments when no guard was used to hold the electrode away from the gastric mucosa there were marked discrepancies between the pH values given by the gastric electrode and those obtained from the aspirated specimen. The use of a guard only partially corrected these discrepancies and the results found under these conditions were similar to those recently reported by Eyerly and Breuhaus (2). As long as such variations between almost simultaneous readings persisted, we felt that the technic was still faulty. Two causes for these great differences in pH were recognized: the glass electrode was being trapped in a spastic antrum where gastric secretion poured directly onto it and where it was reached by little or none of the residual gastric content; and the diffusion in the stomach was extremely slow unless agitation was provided. Although agitation is normally absent in the stomach we believe that uniform mixing should be provided in any method of measuring the efficacy of antacids. Eyerly and Breuhaus (2) attempted such mixing by thrice passing 20 cc. of gastric content backwards and forwards before comparing their readings, but their charts seem to indicate that they did not obtain complete mixing.

We overcome the first obstacle by determining under the fluoroscope the location in the stomach of 250 cc. of barium suspension and by accurately placing the electrode in this location. The second difficulty was