Endoscopic Measurement of Gastric Corpus Mucosal Blood Flow in Conscious Dogs

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This study reports the feasibility of applying the hydrogen gas clearance technique with 3% hydrogen in air and platinum contact electrode to measure corpus mucosal blood flow in conscious dogs. Three percent hydrogen in air is safe and does not produce hypoxia during inhalation. A specially prepared, six-inch polyvinyl chloride pipe was used as a bite-block. The platinum contact electrode, attached to (but not within) a soft rubber suction cup, was passed into the stomach with the aid of a gastroscope. Because of gastric contractions, low, continuous suction was required to maintain the electrode in contact with the corpus mucosa. Stable baseline corpus mucosal blood flow measurements were obtained on control and experimental days in five of 10 dogs. In these five dogs during 2 μg/kg/hr pentagastrin infusion, which induced submaximal acid secretion, corpus mucosal blood flow and gastric acid output were increased significantly (P < 0.05) by 26 ± 4% and 238 ± 79%, respectively. These increases were similar to those previously observed in anesthetized rats, cats, rabbits, and dogs. In an anesthetized rat study, the measurement of corpus mucosal blood flow was found to be unaffected by the low continuous suction. Since the use of 3% hydrogen in air is safe, the technique deserves to be further evaluated in human studies.

Measurement of gastric mucosal blood flow is important for the understanding of both physiological and pathological events occurring in the stomach. Blood flow plays an important role in acid secretion. Adequate mucosal blood flow is also vital in maintaining the integrity of the gastric mucosa. The various techniques that have been used for the measurement of gastric mucosal blood flow can be summarized as follows. The aminopyrine clearance (1, 2), the 99mTc clearance (3), and the neutral red clearance (4-6), provide estimates of mucosal blood flow to the entire glandular stomach. The radiolabeled microsphere techniques (7) and various indicator clearance methods (8, 9) allow focal measure-
velocimetry technique for the measurement of mucosal red blood cell velocity. The technique detects changes in red blood cell velocity, but does not provide actual flow values and requires absolutely no movement of the tissue under study.

In selecting a technique from among this myriad of possibilities, we made our choice based on the following criteria: (1) The technique must be safe. (2) It should allow repeated measurements of regional gastric mucosal blood flow. (3) It should allow flow estimates to be made in absolute units. (4) It must be potentially applicable to human studies, preferably via the endoscope. We thought that a variation of the hydrogen gas clearance technique, as described by Murakami et al (12), if validated, would satisfy these criteria. Murakami et al (12) employed 100% hydrogen, which is a potential fire hazard and may produce hypoxia during inhalation. We chose 3% hydrogen to avoid these drawbacks.

We performed our initial validation experiments for the hydrogen gas clearance technique using 3% hydrogen in air and platinum contact electrodes in anesthetized rats and rabbits (16). The following report describes the measurement of corpus mucosal blood flow in conscious dogs through the gastroscope.

MATERIALS AND METHODS

Mucosal Blood Flow Measurements By Hydrogen Gas Clearance Technique. The hydrogen gas clearance technique (12, 16, 17) takes advantage of the dissociation of molecular hydrogen into H⁺ and e⁻ at the surface of the platinum electrode. When the circuit is completed with a Ag-AgCl reference electrode, a current can be measured via a polarographic unit (Val Tech Electronics, Sherman Oaks, California), and recorded on a chart recorder (Gilson Medical Electronics, Middleton, Wisconsin). In vitro testing has shown that the size of the electrode current is proportional to the concentration of molecular hydrogen in the tissue in contact with the platinum electrode and is unaffected by pH changes in the region of the electrode (12, 16, 17). The platinum electrode is placed in contact with the gastric mucosa. Three percent hydrogen is administered via inhalation for 10-15 min until full tissue saturation with hydrogen is achieved. After discontinuation of the external hydrogen, the current tracing gradually falls. Since the hydrogen in the gastric mucosa can be removed only by blood perfusing it, the rate of fall of the electrode current provides an estimate of blood flow. Points along the desaturation curve are plotted on semilogarithmic paper. Blood flow in ml/min/g, is estimated by the equation 0.693/T₂, where T₂ is the halftime, in minutes, of the desaturation curve. Results are expressed as ml/min/100 g for comparison with data in the literature. Readers who desire a more detailed discussion of the equations used should consult references (12, 17, 18).

Platinum Electrode. A platinum wire (A-M Systems, Inc., Everett, Washington) with a diameter of 0.007 in. was wound around a small glass capillary tube and secured inside the tip of a Teflon tube by epoxy (16). The electrode was then attached adjacent to, but not inside, a small soft rubber suction cup. A second Teflon tube was secured to the center of the suction cup through which suction would be applied (Figure 1).

Animal Preparation. Ten mongrel dogs, each weighing 15-20 kg and trained to stand still during secretory studies, were used. These dogs all had chronic gastric fistulas implanted months before the study. A 6-in. polyvinyl chloride pipe (OD 3.2 cm, ID 2.2 cm) was made into a bite-block by drilling a 2-cm-diameter hole through the center. The polyvinyl chloride pipe was then placed lengthwise across the dog's mouth with the center hole lined up along the orosophageal axis.

Endoscopic Placement of Platinum Electrode and Measurement of Corpus Mucosal Blood Flow. The technique for endoscopic placement of the platinum electrode was as follows. A blunt forceps was passed through one of the biopsy channels of a double-channel endoscope (Olympus GIF-2T). The platinum electrode and suction cup was grasped by the blunt forceps (Figure 2). The endoscope with attachment was then inserted through the center hole in the bite-block and passed into the dog stomach. Once the endoscope was inside the stomach, the gastric lumen was inflated to allow retroflexion of the tip of the endoscope. The tip of the blunt forceps was advanced, placing the suction cup and the platinum electrode against the corpus mucosa. Low continuous suction, 80 mm Hg negative pressure, with a Regu-Gage suction device (National Cylinder Gas Division of Chemetron Corp., St. Louis, Missouri), which is attached to wall suction was started to maintain the suction cup and platinum electrode in continuous contact with the mucosa. Without the suction, the platinum electrode could not be maintained in adequate contact with the mucosa for a sufficiently long period of time to allow measurements to be made. The reference electrode (Ag-AgCl) was conveniently inserted into either a gastric or a duodenal fistula. The electrode current was registered on the Gilson chart recorder. After a stable baseline was achieved, 3% hydrogen in air was administered via a mask placed over the mouth and nose of the dog. The hydrogen was administered for approximately 15 min until the current tracing reached a plateau. The mask was then removed and the desaturation current tracing continued for the next 15 min until the tracing returned to a stable baseline. The stomach was deflated to minimize escape of hydrogen gas into the gastric lumen. Gastric acid output was collected continuously at 15 to 20-min intervals via the gastric fistula. Saline at 30 ml/hr was infused intravenously, during two initial baseline blood flow measurements. Pentagastrin 2 μg/kg/hr was then infused for approximately 60 min. Mucosal blood flow was obtained with hydrogen gas clearance during the last 20-30 min of pentagastrin infusion. The volume of gastric acid output was noted for each timed collection. Aliquots of 0.2 ml were titrated using an

Digestive Diseases and Sciences, Vol. 31, No. 6 (June 1986)