Quantitative measurement of blood flow in various areas of small and large intestine

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GEBER, WILLIAM F. Quantitative measurement of blood flow in various areas of the small and large intestine. Am. J. Physiol. 198(5): 985-986. 1960.—A direct method is presented for the continuous quantitative measurement of blood flow in various areas of the small and large intestine. The mean blood flows of the duodenum, jejunum, ileum and descending colon were 1.39, 0.98, 0.83 and 0.73 ml/gm wet tissue/min. The cannulation of the intestinal artery to any intestinal area does not appear to interfere with the blood flow or pressure to the area. With proper precautions, a preparation will last 5 hours before measurable changes in blood flow and pressure occur.

The evidence for the existence of a physiologic or metabolic gradient throughout the gastrointestinal tract has accumulated over a period of many years (1-3). Anatomical gradients also have been studied (4, 5). Variations and gradations in the rate of rhythmic contraction have been extensively studied by many workers in the field (6-8). The present study was made as a preliminary step in the investigation of the relationship of blood flow and pressure to various functional activities of the different areas of the intestinal tract.

Methods

Studies were performed on a total of 40 dogs (15.0-33.2 kg) anesthetized with sodium pentobarbital. Ten animals were used for the blood flow studies on each of the selected areas. Food was removed from the cages 18 hours, water 1 hour, before beginning the experiment.

A mid-line incision was made using an electrocautery and the general intestinal area to be studied was prepared in such a manner as to cause minimal disturbance of the arrangement of the gut. The selected area to be measured was then determined by the following method. An individual intestinal artery (artery B, fig. 1) arising from the superior mesenteric artery was followed visually to its main bifurcation. Each side was then traced to an area of intestinal wall (2 and 3, fig. 1) which appeared to be also supplied by the adjacent intestinal arteries B and C, (fig. 1). By momentarily occluding the intestinal artery to the area to be measured the pressure pulse disappeared in those vessels on the intestinal wall preferentially supplied by the artery in question. In order to check the validity of this demarcation another maneuver was performed during some of the experiments while actually recording blood flow and pressure. Two broad (2 mm) soft linen cloth ligatures were loosely placed around the intestine in the two commonly supplied areas (2 and 3, fig. 1) before recording began. After a control period of 30-60 minutes, both the ligatures were tightened so that the segment was now actually isolated in situ. Neither the flow or the pressure was changed for the duration of the experiment by this isolation procedure. For the determination of the wet weight of the segment it was felt that the length of intestine between the two commonly supplied areas, as determined visually, was a true measure of the distribution of a given intestinal artery.

The intestinal artery was prepared for cannulation by separating it from any visible nerves and connective tissue (mesentry) along its course. Nylon tubing properly beveled and notched near the tip was used to establish an external flow circuit. A simplified electromagnetic blood flow meter (9) with an appropriate sized cannula was then placed in the flow circuit. Upon completion of surgery and before insertion of the cannula, an initial intravenous injection of heparin (10 mg/kg) was given. Subsequent injections of 1 mg/kg were given every hour thereafter.

Intestinal artery blood pressure was measured by a Statham transducer with a no. 20 gauge needle inserted through the wall of the nylon tubing to measure lateral pressure without interfering with blood flow.

Throughout the experimental period, usually 4-5 hours, the gut was kept covered as much as possible with a minimal exposure to allow visual observation of the area being measured along with the two adjoining areas on either side.

Simultaneous recordings of femoral artery blood flow and pressure were made along with respiration in order to evaluate any changes which might occur in intestinal flow and pressure.

All recording was on a Sanborn 150 six-channel recorder.

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2 Established Investigator, South Dakota Heart Association.
RESULTS

Table 1 shows the results obtained in each of the areas measured. All individual values represent a blood flow that was maintained for at least 2 hours. In those experiments where additional procedures were carried out, i.e., drug administration, nerve stimulation, etc., blood flow was in most instances maintained at the original control level of flow for an additional period of time.

In spite of the removal of food 18 hours before beginning the experiments, undoubtedly there must have existed a rather wide variation in the time of emptying of the intestine.

Since there is no exact method available for the determination of the degree of the postabsorptiive state in the individual animal it is rather difficult to designate the results as absolute basal blood flow rates. No grossly evident food was found at the end of each experimental period at which time the measured segment was removed and washed free of lumenal contents. The data presented probably represent the maximum basal blood flow existing under the conditions of the experiment.

DISCUSSION

The problem of measurement of intestinal blood flow has received relatively limited study with most preparations being of the indirect or isolated type (9-11). Several major objections may be raised against both of these approaches. An isolated method applied to the measurement of blood flow in an area of the intestine does not allow the intestine to function in its usual anatomical and physiological environment. Since the vasculature of any given area of the intestine appears to be part of a combination of parallel and series arrangements, by isolating an area, the relative response relationship to adjoining areas is changed or eliminated.

The present state of development of the indirect methods of blood flow measurement is such that quantitation is rather difficult to obtain with any degree of certainty under many experimental conditions.

Objections to the direct method of measurement are that it necessitates the use of an anticoagulant, the blood vessel must be opened and an external flow circuit inserted using a cannula. As far as can be determined the use of heparin does not significantly affect the blood flow since direct infusions of 10-20 mg/kg into the intestinal artery increase blood flow 5-15% for varying but limited periods (5-15 sec.). Lesser amounts of heparin have little or no effect.

The most serious objection and seemingly the most difficult one to overcome is the insertion of the cannula into the blood vessel. By having a wide range of cannula with varying internal diameters on hand and always selecting one slightly larger than the vessel to be cannulated, little or no change in the normal resistance value at the cannulation area is produced. This was determined in a number of experiments by measurement of blood pressure at several areas along the blood vessel above and below the cannula before and after cannulation.

REFERENCES

2. Evans, C. L. J. Physiol. 58: 22, 1923.

Table 1. Area Blood Flow

<table>
<thead>
<tr>
<th>Area</th>
<th>Blood Flow</th>
<th>Mean ± S.E.</th>
<th>*Descending</th>
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</thead>
<tbody>
<tr>
<td>Duodenum</td>
<td>1.20</td>
<td>0.98±0.13</td>
<td>0.73±0.09</td>
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<tr>
<td>Jejunum</td>
<td>1.07</td>
<td>0.73±0.08</td>
<td>0.37±0.03</td>
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<tr>
<td>Ileum</td>
<td>0.95</td>
<td>0.80±0.06</td>
<td>0.59±0.07</td>
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<tr>
<td>Colon</td>
<td>0.70</td>
<td>0.70±0.09</td>
<td>0.70±0.09</td>
</tr>
</tbody>
</table>

Values expressed in ml/gm wet tissue/min.