Effects of Perfusion Rate and Glucose Concentration on Glucose Absorption in Intestinal Thiry-Vella Loop in Sheep

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ABSTRACT. The effects of the perfusion rate and glucose concentration in perfusate on glucose absorption in the intestinal Thiry-Vella loop of conscious sheep were studied. When 10 mM glucose was perfused at the rates of 0.5, 1, 2 and 4 ml/min, the absorption rates were 77.1±2.2, 54.9±2.3, 31.6±2.1 and 12.9±0.3%, respectively. When 5, 10, 20 and 40 mM glucose solutions were perfused at 1 ml/min, the absorption rates were 75.5±1.7, 52.2±2.2, 29.4±1.9 and 19.5±0.1%, respectively. We conclude that the perfusion of 10 mM glucose solution at 1 ml/min, in which about a 50% absorption rate was obtained, are the optimal conditions for the study of glucose absorption in the intestinal loop of sheep. — KEY WORDS: glucose absorption, intestinal loop, sheep.


The oral rehydration solution containing glucose has been shown to be effective in patients with secretory diarrhea [5]. However, the glucose absorption during increased secretion of intestine had not been studied in ruminants. The technique of the intestinal Thiry-Vella loop [7] has been used for intestinal absorption in the dog [3, 2], rat [10], rabbit [11] and sheep [1]. We consider that this technique is useful in assessing the interaction between intestinal absorptive and secretory functions in conscious animals. However, the appropriate experimental conditions for glucose absorption in sheep have not been reported. This study was designed to determine the optimal perfusion rate and glucose concentration in perfusate for measuring glucose absorption in the intestinal Thiry-Vella loop of sheep.

Three mature male sheep weighing 42 to 46 kg were used. They were kept in individual crates and fed orchard grass hay (100 g) and lucerne pellets (1,000 g) once daily at 19:00. Water was available ad libitum. After a 36 hr fast, the animals were anesthetized with xylazine (0.4 mg/kg) and halothane, and laparotomy was done. A jejunal segment approximately 20 cm long was isolated while fully maintaining mesenteric circulation. Silicone catheters (ID 4 mm, OD 7 mm) were fitted to both ends of the intestinal segment by purse string sutures and the catheters were exteriorized through the right lateral abdominal wall. The continuity of the remaining intestinal tract was restored by end-to-end anastomosis and returned to the abdominal cavity. A week after surgery, luminal perfusion of the Thiry-Vella loop was begun. In every experiment, the outflow during the first 30 min of the 150 min-perfusion period was not collected so that the inside of the loop could be washed with the outflow. During the rest of the period, the outflow from the loop was collected every 10 min. Glucose solution with its osmolality adjusted to 308 mOsm/kg by adding NaCl was perfused at 38°C. Polyethylene glycol 4,000 was added to the perfusate at a concentration of 1 mg/ml as a non-absorbable marker. To examine the effect of the perfusion rate on glucose absorption, 10 mM glucose solution was perfused at 0.5, 1, 2 and 4 ml/min with peristaltic pump (SJ-1211H, ATTO Co., Tokyo). The effect of the glucose concentration in the perfusate on glucose absorption was examined by perfusing 5, 10, 20 and 40 mM glucose solution at 1 ml/min. The amount of glucose which disappeared when passed through the loop was expressed as the net absorption of glucose. The rate of disappearance was also calculated as a percentage of glucose input, and expressed as the rate of absorption (%). The order of experiments was random to exclude post-operative effects. Animals were used twice at the same perfusion rate and glucose concentration within three weeks after surgery.

The glucose concentration was estimated by the glucose oxidase method [9]. Polyethylene glycol was determined according to the method of Hyden [8] and the rate of recovery of PEG was 98.5±5.0%. All results were expressed as the mean±SEM.

Net absorption of glucose in the intestinal Thiry-Vella loop measured every 10 min was shown to be stable during the perfusion period at every perfusion rate and glucose concentration in the perfusate. Mean net absorption of glucose was increased as the perfusion rate was increased in the range 0.5 to 2 ml/min. Perfusion at 4 ml/min, however, resulted in submaximal absorption (Fig. 1). The rate of absorption was decreased as the perfusion rate was increased. Values at 0.5, 1, 2 and 4 ml/min were 77.1±2.2, 54.9±2.3, 31.6±2.1 and 12.9±0.3%, respectively (Fig. 1). When the perfusion rate was fixed at 1 ml/min, a positive
Fig. 2. Effect of glucose concentration in perfusate on mean net absorption (○) and absorption rate (●) of glucose during 120 min perfusion period for in the intestinal loop of sheep. Values are shown as the mean±SEM of 6 observations.

relationship between net absorption and the glucose concentration in the perfusate in the range 5 to 40 mM was observed (Fig. 2). However, the absorption rate was negatively related to the glucose concentration in this range as shown by the values 75.5±1.7, 52.2±2.2, 29.4±1.9 and 19.5±0.1% at 5, 10, 20 and 40 mM glucose solutions, respectively (Fig. 2).

The 10 mM glucose is the average concentration in the small intestine in the physiological condition of monogastric animals and 5 to 40 mM glucose is the physiological range because Ferraris et al. [4] reported that the glucose concentration in the small intestine averaged 0.4–24 mM and ranged 0.2 to a maximum of 48 mM on most nearly physiological diets. Perfusion rates are also considered to be in the physiological range because the flow rate of fluid in the mid intestine was reported as 184 ml/hr in sheep [6]. The glucose absorptive mechanism was almost saturated at over 2 ml/min infusion of 10 mM glucose. Except for this, the present results show that increasing the glucose supply increases net absorption but decreases the absorptive efficiency. The half maximum net absorption was shown to be obtained below 0.5 ml/min infusion of 10 mM glucose and below 5 mM glucose at 1 ml/min infusion. These conditions are not appropriate for the experiment to a observe stimulative effect because over 80% of the glucose infused is absorbed without stimulation. We consider that the experimental conditions showing approximately a 50% absorption rate in the unsaturated condition of the glucose absorptive mechanism is preferable in detecting both the stimulatory and inhibitory effects of experimental treatments on intestinal absorption. We conclude that the perfusion of 10 mM glucose solution at 1 ml/min, in which about a 50% absorption rate was obtained, is the optimal condition for the study of glucose absorption in the intestinal Thiry-Vella loop of sheep.

REFERENCES