Contribution of diffusive pathway in intestinal absorption of glucose in rat under normal feeding condition

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Summary. Luminal concentration of glucose determined by a specific enzymatic method was about 50 mM after meal in rat jejunum. The diffusive pathway was suggested to have an important role in intestinal absorption of glucose.

It is well documented that glucose is actively absorbed in the small intestine by a specific, phlorizin-sensitive transport system. Recently, Debnam and Levin[1] showed that a considerable fraction of glucose absorbed from the intestinal lumen was not inhibited by phlorizin in vivo, and might be absorbed by the diffusive pathway. The ratio of active/passive absorption decreased with increase in the luminal concentration of glucose. Therefore, to obtain correct information about the intestinal absorption of glucose during normal digestion, it seems to be important to know the luminal concentration of glucose in vivo, with special reference to food intake. In almost all works reported[2,3], the luminal concentration of glucose was measured as reducing sugar, which contains not only glucose but also maltose, isomaltose and other reducing substances. In the present study, we measured the luminal concentration of glucose by a specific enzymatic method in rat jejunum, and on the basis of study on dependency of the absorption rate of glucose on the luminal concentration of glucose, contributions of the diffusive and the active pathways in the intestinal absorption of glucose in vivo were estimated.

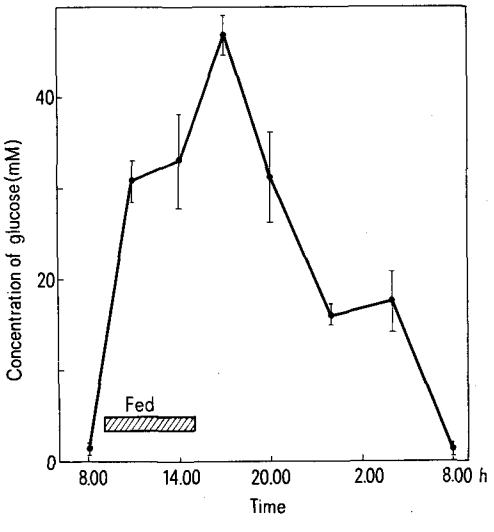

Fig. 1. Glucose concentration of the intestinal fluid in rats fed from 9.00 to 15.00 h for 2 weeks. Each point represents the mean value for 5 rats with the SE.

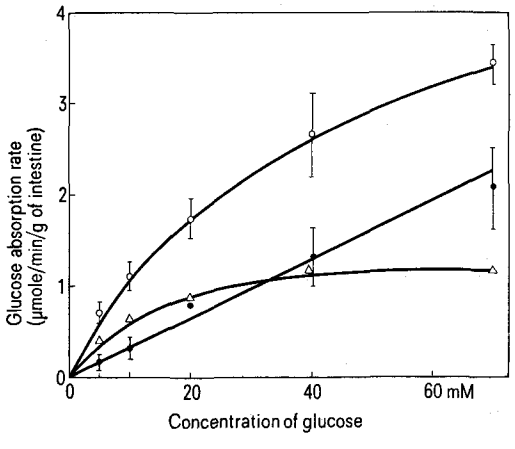

Fig. 2. Glucose absorption rate in vivo at various concentrations of glucose. ●, Addition of 0.5 mM phlorizin; ○, no addition, △, the difference between the rates in the absence and presence of 0.5 mM phlorizin. Each point represents the mean value for 5 rats with the SE.

Methods. Male Wistar rats (200–300 g) were kept under conventional lighting conditions with a dark night, and fed on the laboratory chow containing 52% starch (Oriental Yeast Co., Tokyo) from 9.00 to 15.00 h every day for 2 weeks. To determine the luminal concentration of glucose, 1 group of rats was decapitated at specific times of day during the ensuing 24 h. Upper half of the small intestine was rapidly removed, and the contents of the segment were collected and spun in a refrigerated centrifuge at 8000 × g for 20 min. The resulting supernatant was used for determination of glucose by the specific enzymatic method using hexokinase and glucose-6-phosphate dehydrogenase[4]. In preliminary experiments, we certified that maltose and isomaltose had no effect on the glucose assay, and the amount of glucose added to the supernatant was completely recovered, showing that a true concentration of glucose in the intestinal fluid could be estimated by this method. In order to study the glucose absorption in vivo, another group of the rats was anaesthetized (i.v. injection of 4 mg sodium pentobarbital per 100 g b.wt), laparotomized, and 20 ml of Krebs-Ringer bicarbonate test solution (pH 7.4) containing various concentrations of glucose was circulated through the lumen of upper half of the small intestine for 15 min at 37 °C. These tests were performed from 12.00 to 15.00 h. To examine the glucose absorption by the diffusive pathway, 0.5 mM phlorizin was added to the test solution. Other procedures were essentially the same as reported by Furuya and Yugari[5]. The glucose absorption rate was calculated from the decrease in glucose concentration in the test solution, with correction of the volume change of the test solution during circulating period.

Results and discussion. As shown in figure 1, the luminal concentration of glucose changed greatly before and after meal. The glucose concentration was less than 2 mM immediately before the start of the feeding time, increased

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sharply after meal, reached the maximum level of about 50 mM around the end of the feeding time, and thereafter decreased gradually. As expected, the glucose concentration estimated by the specific enzymatic method was much lower than the free reducing sugar concentration, about 110 mM, reported by Cole[2], who examined only during the feeding time. The difference may be due to maltose, isomaltose and other reducing substances in the intestinal fluid.

Figure 2 shows the glucose absorption rate in vivo during the feeding time at various luminal concentrations of glucose either in the presence or absence of 0.5 mM phlorizin. The glucose absorption rate in the presence of phlorizin (phlorizin-insensitive component) increased proportionaly with increase in the glucose concentration in the lumen. The difference between the rates in the absence and presence of phlorizin (phlorizin-sensitive component) was saturable, and the half-maximal concentration of glucose was about 10 mM. The rate of the phlorizin-sensitive absorption was larger than that of the phlorizin-insensitive absorption up to the glucose concentration of about 35 mM, but above this concentration, the reverse is the case. These results are in good agreement with those reported by Debnam and Levin[1], and could best be explained by supposing that the phlorizin-sensitive component and the phlorizin-insensitive one represent the absorption via the active transport system and the diffusive pathway, respectively.

It has been reported that the digestive and absorptive functions of the small intestine exhibit circadian variations, synchronizing with the feeding-fasting cycle[5-9]. In preliminary experiments, the glucose absorption rate during the nonfeeding time (24.00–3.00 h) was found to be lower than that during the feeding time shown in figure 2 either when phlorizin was present or absent, but the ratio of active/passive absorption did not change at each concentration of glucose. All these results strongly suggest that glucose is absorbed mainly via the active transport system during the nonfeeding time when the luminal concentration is low, but a larger fraction of glucose is absorbed by the diffusive pathway during the feeding time because of high luminal concentration of glucose.

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Experimental hydrocephalus following mechanical increment of intraventricular pulse pressure[1]

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Summary. Experimental hydrocephalus has been induced in lambs by artificial increase of the amplitude of intraventricular cerebrospinal fluid (CSF) oscillations related to arterial pulsations, without concomitant changes of the mean CSF-pressure. The characteristics of this hydrocephalus demonstrate that the intraventricular CSF-pulsations can play a role in the genesis of ventricular dilatation. Such a method may be used to produce an original model of hydrocephalus independent of changes of CSF-circulation or absorption.

Cerebrospinal fluid (CSF)-pulsations have been recognized for many years[3]. Their origin has been related to the arterial pulse waves[4-9] or to the venous pulse waves[10,11], or to a combination of both[12,13]. Bering[6] suggested that CSF-pulsations, as well as CSF-circulation, depend entirely on the pumping effect due to the choroid plexus systolic expansion. As the choroid plexus fills with blood, a local CSF-pressure wave is generated. This wave is normally absorbed in part by the ventricular wall, in part by pumping CSF out from the ventricular system and by compressing veins in the subarachnoid spaces.

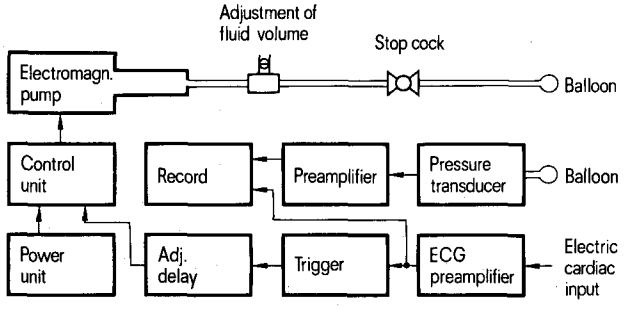

Fig. 1. Schematic drawing of the experimental electronic and hydraulic arrangement for producing and recording intraventricular CSF-pulses.

Bering[7] also stated that this local force generated by the choroid plexus accounts for the ventricular dilatation in a blocked ventricle, independently of the back pressure due to the arrest of CSF-flow. Experiments by Wilson and Bertan[14] supported Bering's thesis on the pathogenetic effect played by undamped pulse waves. In fact, the combination of intracisternal injection of lampblack and of occlusion of the anterior choroidal artery of one side in dogs, caused the enlargement of the ventricle with intact vascular supply and had no effect on the contralateral one. Milhorat[15] found that hydrocephalus invariably occurred in plexectomized monkeys in which ventricular obstructions of various types were performed, except in case of extensive plexectomy scars. On this basis, he concluded that the choroid plexus is not essential in generating a pulsatile mechanism for expanding the ventricle in the hydrocephalus. In dogs in which one foramen of Monro was plugged while the other one was pervious, Sybayan and al.[16] showed that the mean CSF-pressure was always higher in the blocked and dilated ventricle, so that the rise in the mean pressure could be considered 'a necessary factor responsible for ventricle enlargement'.

The aim of this report is to bring forward new experimental data suggesting the importance of abnormally high intraventricular CSF-pulsations in the development of hydrocephalus, even when the mean CSF-pressure