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Water absorption from human jejunum in the presence of systemic bacterial infection

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Summary

Systemic bacterial infections significantly reduce the jejunal absorption rate of glucose when that sugar is presented at a concentration comparable to that used in oral rehydration fluids. In order to decide whether such infections exert an effect on water transfer also, net water absorption rate from normal saline was determined, using a jejunal perfusion technique, in 6 patients with systemic bacterial infections and in 6 controls; the difference in the mean rate was not significant. In similar groups, previously studied, systemic infections had no significant effect on the kinetics of net water absorption from iso-osmotic glucose (56, 139 and 278 mmol l^{-1}), glycine (100 mmol l^{-1}) or glycylglycine (50 mmol l^{-1}) solutions; slopes of linear regressions for net water and solute absorption rates were not significantly different from controls. Net water absorption rates from iso-osmotic glucose (200 mmol l^{-1}) and glycine (100 mmol l^{-1}) solutions were compared in Africans (who have a high incidence of sub-clinical infection), Arabs and Europeans; slopes of linear regressions for net water and solute absorption rates were similar in the three groups. Systemic bacterial infections do not significantly affect water absorption, and do not therefore affect oral re-hydration regimes which are now widely used in tropical countries; however, because glucose absorption is depressed by such infections there is some diminution in the overall rate of water absorption.

Key words: water absorption; jejunal absorption; systemic bacterial infection; human jejunum; absorption; infection; jejunum.

Introduction

Oral glucose- and glycine-electrolyte solutions, which contain approximately 120 mmol l^{-1} of solute, have become widely used in the rehydration of

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patients with acute diarrhoeal disease, especially in tropical countries (Nalin and Cash, 1970; Nalin et al., 1970; Cash, 1979). That technique is of value in the presence of bacterial enterotoxins which are responsible for net water secretion to the jejunal lumen via cyclic A.M.P. (Turnberg, 1978); *Vibrio cholerae, Escherichia coli, Clostridium welchii, Staphylococcus aureus, Shigella dysenteriae* and *Klebsiella pneumoniae* stimulate luminal water secretion by that mechanism. A significant impairment of glucose absorption has been demonstrated in the presence of systemic bacterial infection (Cook, 1971, 1973a, 1974a and b, 1977) in the absence of jejunal mucosal damage; the mechanism of that is unknown.

The present investigation was undertaken to determine whether there is an impairment in absorption, or even a net secretion of water to the jejunal lumen, from saline and glucose- and glycine-electrolyte solutions, in patients with systemic bacterial infections; that could be important in re-hydration in the tropics. Using results from three previous studies a comparison has been made of water absorption rate from a glucose-electrolyte solution in three different ethnic groups.

Material and methods

Patients

The subjects were 12 Zambian African inpatients at The University Teaching Hospital, Lusaka, who had not been studied before, and who agreed to investigation after full explanation through an interpreter. They came from several different Zambian tribes. Six had a bacterial infection (lobar pneumonia in 3, and bilateral cavitating pulmonary tuberculosis in 3) (infection group); 6 had no evidence of an infection (control group). Mean age was 34 (22–54) and 32 (16–54) years, and bodyweight 52 (41–58) and 54 (45–65) kg, respectively; two in the infection and one in the control group were women. Two of the infection group (one with pneumonia and one with tuberculosis) were pyrexial. Those with tuberculosis had *Mycobacterium tuberculosis* in the sputum. All diagnoses were confirmed by chest radiography. Mean haemoglobin concentrations were 134 (116–141) and 157 (137–186) g l^{-1}, respectively. Mean serum albumin, total, and γ-globulin concentrations were: 32 (29–37) and 39 (33–44), 46 (40–54) and 40 (31–60), and 22 (16–31) and 20 (13–32) g l^{-1}, in the two groups respectively. Mean serum immunoglobulin concentrations (Cook and Lewis, 1975) were: IgG 17 (8–22) and 16 (10–26), IgA 3.5 (1.7–5.3) and 3.1 (2.0–4.7), IgM 1.7 (1.0–2.4) and 1.5 (0.7–3.1), and IgD 0.09 (0–0.19) and 0.17 (0.04–0.38) mg ml^{-1}. Mean serum urea concentrations were 30 (19–50) and 21 (12–26) mg dl^{-1}.

Mean xylose excretion after a 25 g oral load (Cook, 1972a) was 6.1 (4.5–8.3) and 7.4 (6.9–8.4) g 5 h^{-1}, respectively. Three of the infection group had hookworm ova in the stool; all others had normal stool-microscopy.

Perfusion technique

The perfusion technique has been described (Cook, 1971; 1972b). All subjects were fasted overnight (approximately 12 h), but sips of water were permitted. A double-lumen tube system was used and absorption measured from a 30 cm jejunal segment by reference to a non-absorbable marker (polyethylene glycol 4000, PEG); perfusion rate was 12.0 ml min^{-1}. The perfusion solution contained 300 mmol l^{-1} NaCl and 5 g l^{-1} PEG; distilled water was used in the preparation of the solutions. After a 35 min stabilization period, three consecutive 10-min collections of intestinal content were made by siphonage (perfusion A); the procedure was repeated (perfusion B) and

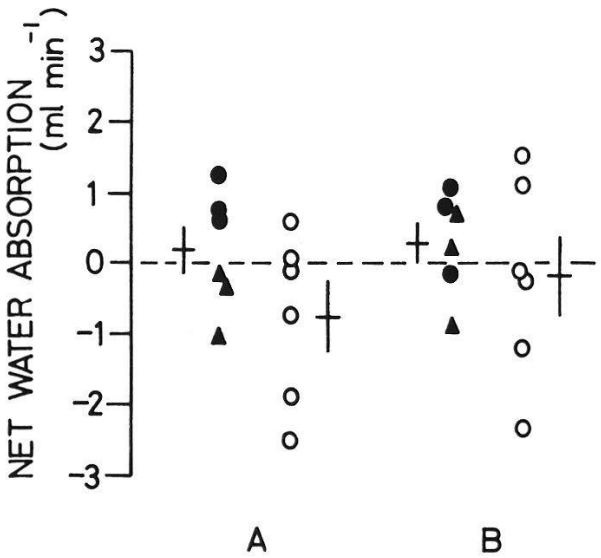

Fig. 1. Net water absorption rates (ml min^{-1} 30 cm of $jejunum^{-1}$) from normal saline in 12 patients during perfusions A and B. ● = lobar pneumonia; ▲ = pulmonary tuberculosis; ○ = control. Mean ± 1 SEM are shown.

further collections made because it was felt that although there was no clinical evidence, marginal dehydration might have been present in the infection group at the start of the investigations. Total perfusion time was 130 min. Mean infusion opening of the tube was 17 (3–31) and 10 (5–27) cm past the duodenojejunal flexure in the infection and control groups, respectively; that had moved by a mean of 4 (0–17) cm distally at the end of the investigation (Cook and Carruthers, 1974). Analytical methods and calculation of results have been described (Cook, 1971).

Analysis of results from previous investigations

In order to determine whether the correlation and slope of linear regression between net water and glucose absorption rates is altered by systemic bacterial infections, results from a previous investigation (Cook, 1971) have been examined. Results for net water, and glycine (Cook, 1973b) and glycylglycine (Cook, 1974c) absorption rates from other investigations have been similarly assessed.

Africans living in Africa frequently have subclinical systemic infections. Therefore, correlations between net water and glucose absorption rates, determined in previous investigations, were compared between them and groups of Arabs and Europeans, who did not have such infections (Cook, 1974d; 1976; 1980); all of those studies were carried out by the same investigator using the same technique.

Student's *t*-test was used for comparison of means; equality of the slopes of calculated regression lines was also compared with the *t*-test.

Results

Fig. 1 summarizes net water absorption rates during perfusions A and B. The mean values for the infection group were 0.18 (–1.03 to 1.24) and 0.28 (–0.88 to 1.06), and for the control group –0.77 (–2.51 to 0.59) and –0.20 (–2.33 to 1.50) ml min^{-1} 30 cm of $jejunum^{-1}$, respectively. The differences are not significant. Linear correlation coefficients (r) for net water absorption rate and serum albumin concentration during perfusions A and B were –0.39 and –0.15

Table 1. Relationships between net water and glucose, glycine and glycylglycine absorption rates in Africans with systemic infections and controls

Solute perfused	Solute concentration (mmol l^{-1})	Infection group				Control group			
		n	Linear regression equation	r	P*	n	Linear regression equation	r	P*
Glucose	56	12	$y = 0.01\,(x) + 0.53$	+0.19	N. S.	9	$y = 0.003\,(x) + 0.59$	+0.14	N. S.
	139	12	$y = 0.18\,(x) + 0.52$	+0.86	<0.001	10	$y = 0.05\,(x) + 1.03$	+0.42	N. S.
	278	12	$y = 0.23\,(x) + 1.03$	+0.73	<0.01	10	$y = 0.17\,(x) + 1.45$	+0.51	N. S.
Glycine	100	15	$y = 6.70\,(x) - 3.09$	+0.63	<0.02	21	$y = 5.83\,(x) - 2.26$	+0.58	<0.01
Glycylglycine	50	16	$y = 4.91\,(x) - 2.90$	+0.58	<0.01	20	$y = 12.48\,(x) - 9.95$	+0.80	<0.001

* N. S. = not significant

Table 2. Relationships between net water and glucose and glycine absorption rates in Africans, Arabs and Europeans

Solute perfused	Concentration (mmol l^{-1})	Ethnic group	n	Linear regression equation	r	P*
Glucose	200	Zambian African	17	$y = 0.13\,(x) - 1.00$	+0.55	<0.05
		Saudi Arabian	14	$y = 0.13\,(x) - 1.05$	+0.77	<0.01
		European	10	$y = 0.09\,(x) - 1.24$	+0.55	N. S.
Glycine	100	Zambian African	21	$y = 5.83\,(x) - 2.26$	+0.58	<0.01
		European	10	$y = 0.10\,(x) - 0.51$	+0.86	<0.01

* N. S. = not significant

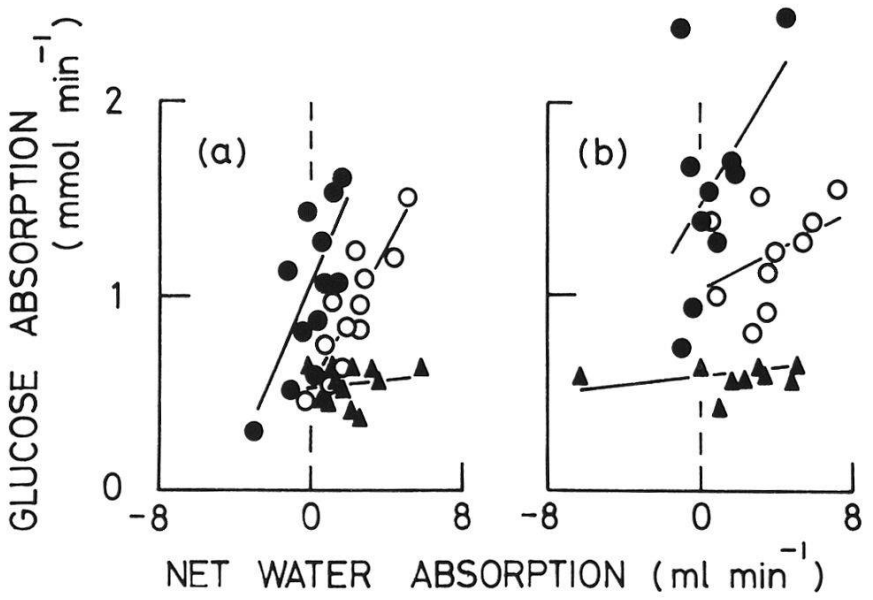

Fig. 2. Correlations between net water and glucose absorption rates from 56 (▲), 139 (○), and 278 (●) mmol l^{-1} iso-osmotic glucose solutions in Africans (a) with systemic infections and (b) controls. Linear regressions are shown for each glucose concentration (Table 1).

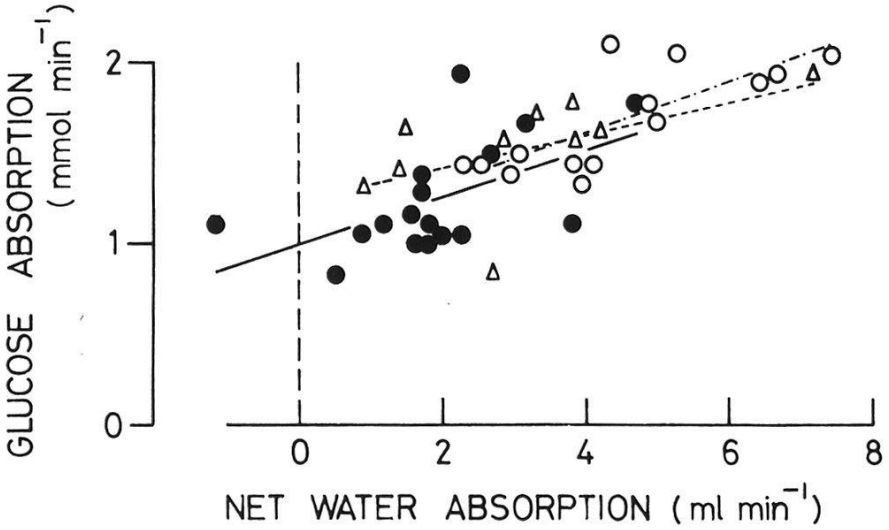

Fig. 3. Correlations between net water and glucose absorption rates from a 200 mmol l^{-1} glucose solution in Africans, Arabs and Europeans. ●, —— = Africans; ○, -·-·-·- = Arabs; △, ------ = Europeans. Linear regressions are shown (Table 2).

(n = 12), respectively. In all except one patient, in the control group, 1–5 fluid stools were passed towards the end, or soon after completion of the perfusions.

Fig. 2 and Table 1 summarize relationships between net water and glucose absorption rates in patients with systemic infections and controls (Cook, 1971); Table 1 summarizes relationships between net water, and glycine and glycylglycine absorption rates in similar groups. The slopes of linear regression are not significantly different.

Fig. 3 and Table 2 summarize correlations and slopes of linear regression

during glucose and glycine perfusions in groups of Africans, Arabs and Europeans; they are not significantly different.

Discussion

The present results clearly show that systemic bacterial infections have no significant effect on the kinetics of water transfer across the jejunal mucosa. Furthermore, water absorption from glucose- and glycine-electrolyte solutions takes place normally in the presence of such infections; those solutions can be used satisfactorally for oral re-hydration. However, because glucose absorption is impaired by such infections (Cook, 1971), there is inevitably a reduction in the overall rate of water absorption, which is solute-linked (Fordtran, 1975).

No evidence of water secretion was found when saline was perfused into the proximal jejunum of the group with systemic bacterial infections; in fact there was mean net absorption, whereas in the controls there was minimal net secretion. Three patients in the infection group had mild hookworm infections, which have been incriminated in malabsorption (Sheehy et al., 1962); however, there is no good overall evidence for that effect (Cook, 1974b). Studies using the same technique as that in the present study have shown that in healthy subjects there is either minimal net absorption (Sladen and Dawson, 1969) or secretion (Hellier et al., 1973) from normal saline; the minor differences in results from those studies were considered to be of technical origin.

Net water absorption kinetics from solutions containing glucose at three different concentrations, and also from glycine and glycylglycine solutions, were also not significantly influenced by systemic bacterial infections (Fig. 2; Table 1). Relationships between net water, and glucose and glycine absorption rates were similar in three ethnic groups studied (Fig. 3, Table 2). All were well-nourished but the Africans had evidence of subclinical systemic infections. The constancy of net water/solute absorption relationships in those three groups is of interest in view of suggested species differences in that association (Fullerton and Parsons, 1956; Diamond and Bossert, 1967; Sladen and Dawson, 1969). In the present study, diarrhoea after saline was usually severe; that is similar to its effect on normal Europeans (Sladen and Dawson, 1969; Hellier et al., 1973) and is further evidence that there is no ethnic difference in water absorption from saline by the small or large intestine.

The present study does nothing to clarify the mechanism of impairment of glucose absorption by systemic bacterial infections. Zinc deficiency which disturbs the functional integrity of the small intestine (Love, A. H. G., unpublished) is common in such infections, and warrants further attention.

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