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Influence of gastric *p*H on gastric and jejunal flora

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EDITORIAL COMMENT The acidity of the gastric contents is an important factor in regulating gastric and intestinal bacterial flora. Other factors, such as stasis and pathological states, are also concerned.

In an *in-vitro* study (Shiner, Waters, and Gray, 1963) cultures of *E. coli* were found unable to survive more than one hour in human gastric juice of *p*H 5 or above. This observation stimulated our interest in the influence *in vivo* of the *p*H of the gastric juice on gastric and jejunal flora.

SELECTION OF PATIENTS

In the first part of this investigation 33 subjects were investigated. Ten (nos. 1 to 10) had previously undergone operations for peptic ulcer (eight Billroth II and one Billroth I partial gastrectomies and one gastroenterostomy) (Table I). Seven patients (nos. 11 to 17) suffered from idiopathic steatorrhoea (Table II). Eight patients (nos. 18 to 25) had pernicious anaemia, untreated or treated (Table III). Eight patients (nos. 26 to 33) had miscellaneous disorders (Table IV). Of these, three had *x*-ray-negative dyspepsia and of the remaining five, one had a gastric ulcer, one duodenal ulcer, one megaloblastic anaemia of intestinal origin, one diarrhoea of unknown cause, and one jejunal diverticulosis.

By choosing these groups of patients we hoped to investigate those with intact stomachs and therefore providing a wide range of gastric *p*H (23 patients) and those in whom direct continuity between the stomach and jejunum had been established by operation (10 patients).

METHODS

All the investigations were carried out on patients when they were fasting.

HISTAMINE TESTS

FULL AUGMENTED HISTAMINE TEST (F.A.H.) This was done on 23 patients: 0·04 mg. of histamine base per kilogram of body weight was given and basal post-stimulation samples of gastric juice were collected over two hours by continuous and hand suction.

MODIFIED AUGMENTED HISTAMINE TEST (M.A.H.) This was done on five patients. They each received the same maximal dose of the histamine base and the only specimen of gastric juice was taken between 30 and 60 minutes later.

'SUBMAXIMAL HISTAMINE TEST' (S.H.T.) This was done on five patients. They received only 0·5 or 1·0 mg. of the base, and, again, the only specimen of gastric juice was taken between 30 and 60 minutes later.

OBSERVATIONS ON GASTRIC ACIDITY In the patients who underwent the full augmented histamine tests the *p*H range was recorded after the maximal doses of histamine had been given. In the others the *p*H of the single specimen taken was recorded.

BACTERIOLOGICAL INVESTIGATIONS

None of the patients was receiving antibiotics when the bacteriological specimens were taken. A throat swab was taken before intubation with the culture capsule (Shiner, 1963). The throat was then sprayed with 1% amethocaine. Precautions against contamination (Shiner *et al.*, 1963) were taken when handling the capsule which was guided into the stomach under fluoroscopic control. A 50 ml. syringe was connected to the upper end of the radioopaque connecting tube, and suction, applied by the syringe, displaced the cap at the lower end of the capsule and allowed gastric juice to enter the capsular space. When there was enough juice it could be drawn through the connecting tube into the syringe. Releasing the suction from the syringe closed the capsule which was then withdrawn.

In 24 of the patients a second sterile capsule was introduced and guided under fluoroscopic control beyond the ligament of Treitz. A syringe filled with sterile water and fitted to an infusion pump was attached to the upper end of the connecting-tube. By this means sterile water was forced at constant pressure and at a given rate into the capsular space. During prolonged intubation this prevented bacteria entering the space through the two possible sites of entry described previously (Shiner *et al.*, 1963). Samples of jejunal juice were obtained in the manner used for gastric samples.

CULTURAL METHODS The throat swabs and the gastric

and jejunal juices were all cultured aerobically and anaerobically on blood agar and MacConkey's agar plates, Robertson's bullock-heart medium and Sabouraud's agar. The results were classified as scanty flora ±, moderate flora ++, profuse flora +++.

Additional bacteriological examinations were made on jejunal biopsies from nine patients (Table V). Two of these patients were numbers 29 and 33 of the previous series. The other seven (nos. 34 to 40) were selected at random. Four of them had had a Polya partial gastrectomy; two had steatorrhoea and one chronic pancreatitis.

As the specimens were to be submitted to bacteriological examination, the suction biopsy tube before intubation was rinsed first with undiluted Milton solution and then thrice with sterile water. It was then passed with its aperture in the closed position. The specimens obtained were examined bacteriologically by Gram-stained smears and cultures. In some of these patients in addition, the gastric and jejunal juices taken by the culture capsule were also investigated. In three of the patients jejunal juice was found in the biopsy capsule (and therefore obtained close to the site of the biopsy). These juices were also examined bacteriologically (see results and Table V).

BIOPSIES

The specimens taken for biopsy were usually multiple. We used the technique of Wood, Doig, Motteram, and Hughes (1949) for the gastric biopsies, the technique of Shiner (1956) for the jejunal biopsies, and the histological classification of Shiner and Doniach (1957).

Gastric biopsies were taken from 13 patients: two with partial gastrectomies (nos. 2 and 3), all seven with idiopathic steatorrhoea (nos. 11 to 17), and four of the patients with miscellaneous disorders (nos. 26, 27, 29, and 31). Efforts were made to take the specimens from the fundus. In patient no. 3, however, the material may have been inadvertently taken from the prepyloric area.

One biopsy (no. 14) is not shown in the appropriate table (Table II) because it was not taken at the same time as the estimation of the *p*H, the cultures of the gastric and jejunal fluids, and the jejunal biopsy.

Jejunal biopsies were taken from 15 patients (nos. 1, 3 to 5, 7, 9, 11 to 17, 29, and 31). These included all those with idiopathic steatorrhoea. Repeat biopsies were made on patient 13.

RESULTS

The results are summarized in Tables I to IV, each table relating to one of the four groups of patients, *viz.*, Table I, partial gastrectomies and gastroenterostomy; Table II, idiopathic steatorrhoea; Table III, pernicious anaemia; and Table IV miscellaneous disorders. The results of the additional bacteriological examinations on the jejunal biopsies of nine patients are summarized in Table VI.

PATIENTS WITH PARTIAL GASTRECTOMY OR GASTROENTEROSTOMY (Table I) Of the 10 patients in thi

TABLE I

TEN PATIENTS WITH PARTIAL GASTRECTOMY OR GASTROENTEROSTOMY

No.	*Sex*	*Age*	*Operation*[1]	*Test*[2]	*Gastric Juice*		*Gastric Biopsy*[4]	*Jejunal Juice Culture*	*Jejunal Biopsy*[5]	*Additional Information*
					pH Range[3]	*Culture*				
1	M	54	P/G (B.II)	F.A.H.	7·3–8·5	Paracolon +	—	—	Normal	
2	M	58	P/G (B.II)	F.A.H.	7·6–8·2	Sterile	P.A.G.	Sterile	—	
3	M	70	P/G (B.I)	F.A.H.	7·2–7·8	*Strep. viridans* Pneumococci Diphtheroids *E. coli* +	Normal prepyloric mucosa	Sterile	Normal	
4	M	53	P/G (B.II)	F.A.H.	6·6–7·6	Sterile	—	Sterile	Normal	
5	F	73	P/G (B.II)	F.A.H.	7·1–7·6	*E. coli* ++	—	*E. coli* ++	Normal	Megaloblastic anaemia after operation
6	M	52	P/G (B.II)	F.A.H.	4·7–7·7	*E. coli* + Proteus +	—	See text	—	
7	F	35	P/G (B.II)	F.A.H.	6·9–7·9	Throat commensals	—	Sterile	Normal	Iron-deficiency anaemia
8	M	64	P/G (B.II)	F.A.H.	2·0–2·9	*Strep. viridans* + Neisseriae + Diphtheroids +	—	Sterile	—	Vagotomy Roux-en-Y anastomosis
9	F	55	P/G (B.II)	M.A.H.	1·6	Sterile	—	*E. coli* +++	Normal to P.V.A.	Pancreatectomy and partial duodenectomy
10	M	62	G/E	F.A.H.	6·6–7·4	*K. aerogenes* +	—	*E. coli* +++ *K. aerogenes* +	—	

[1]P/G (B.II) denotes partial gastrectomy by Billroth II operation; P/G (B.I) the same by Billroth I, and G/E gastroenterostomy.
[2]F.A.H. denotes full augmented histamine test and M.A.H. modified augmented histamine test (see text).
[3]Recorded after maximal doses of histamine (see text).
[4]P.A.G. denotes partial atrophic gastritis.
[5]P.V.A. denotes partial villous atrophy.

group, seven were male and three were female. Their ages varied from 35 to 73 years.

pH of the gastric juice In two patients (nos. 8 and 9) it was acid. In one (no. 6) at its most acid it fell just below 5·0 and in the other seven patients it never fell below 6·0.

Gastric juices of three patients (nos. 2, 4, and 9) were sterile. Two (nos. 7 and 8) grew throat commensals similar to those isolated from their throats. Patient no. 3 grew scanty *E. coli* in addition to throat commensals. Patient no. 1 grew scanty paracolon, patients nos. 5 and 6 profuse *E. coli*, and patient no. 10 profuse *K. aerogenes*.

Gastric biopsies were performed in only two patients (nos. 2 and 3). The former showed a partial atrophic gastritis and the latter a normal mucosa of prepyloric type.

Jejunal juices were obtained from patients nos. 2 to 10 only. Most of these were taken at the same time as the gastric specimen but that from patient no. 6 was obtained subsequently to the other investigations on him. Five of the juices (nos. 2, 3, 4, 7, and 8) were sterile. Nos. 5, 6, 9, and 10 all yielded *E. coli* and no. 10 grew *K. aerogenes* as well.

Jejunal biopsies were taken in six patients (nos. 1, 3, 4, 5, 7, and 9). All were normal except no. 9 which showed the slight shortening and irregularity of the villi of early partial villous atrophy.

TABLE II

SEVEN PATIENTS WITH IDIOPATHIC STEATORRHOEA

No.	Sex	Age	Test[1]	Gastric Juice		Gastric Biopsy[3]	Jejunal Juice Culture	Jejunal Biopsy[4]
				pH Range[2]	Culture			
11	M	54	F.A.H.	1·9–8·4	Sterile	P.A.G.	Sterile	S.V.A.
12	F	45	F.A.H.	7·4–7·8	*Strep faecalis* ++ *E. coli* +++	S.G.A.	*Strep. faecalis* ++ *E. coli* +++	S.V.A.
13	M	52	F.A.H.	1·6–6·4	*E. coli* +	P.A.G.	Sterile	S.V.A.
14	F	57	S.H.T.	2·5	Sterile	—	Sterile	S.V.A.
15	F	38	S.H.T.	4·3	Sterile	Normal	*Strep. faecalis* +	S.V.A.
16	M	35	F.A.H.	1·2–1·3	Sterile	Normal	—	S.V.A.
17	M	58	S.H.T.	1·8	Sterile	P.A.G.	Sterile	P.V.A.

[1]F.A.H. denotes full augmented histamine test and S.H.T. submaximal histamine test (0·5 or 1·0 mg. histamine given and only one specimen of gastric juice obtained).
[2]Recorded after maximal doses of histamine (see text).
[3]P.A.G. denotes partial atrophic gastritis.
[4]S.V.A. denotes subtotal villous atrophy and P.V.A. partial villous atrophy.

TABLE III

EIGHT PATIENTS WITH PERNICIOUS ANAEMIA

No.	Sex	Age	Test[1]	Gastric Juice		Jejunal Juice Culture
				pH Range[2]	Culture	
18	M	75	F.A.H.	7·5–8·3	Sterile	—
19	M	39	F.A.H.	7·2–8·3	Sterile	Sterile
20	F	79	F.A.H.	7·5–8·2	Sterile	—
21	F	72	F.A.H.	7·3–7·8	*Streptococcus viridans* +++ Pneumococci ++ Neisseriae +	*Streptococcus viridans* +++ Pneumococci ++ Neisseriae +
22	M	63	M.A.H.	7·1	*Streptococcus viridans* +++ Diphtheroids ++ *E. coli* +++	*E. coli* +
23	M	48	F.A.H.	7·2–8·1	*Streptococcus salivarius* + *E. coli* + Lactobacilli +	*E. coli* +
24	M	56	F.A.H.	7·7–7·9	*Streptococcus salivarius* ++ *E. coli* + Lactobacilli + Bacteroides +	*Streptococcus salivarius* + *E. coli* + Lactobacilli + Bacteroides +
25	F	67	F.A.H.	7·6–8·1	*Streptococcus viridans* ++ *E. coli* +	—

[1], [2] See above.

PATIENTS WITH IDIOPATHIC STEATORRHOEA (Table II) The seven patients (nos. 11 to 17) comprised four males and three females, their ages ranging from 35 to 58. Free hydrochloric acid in the gastric juices was found in all except no. 12.

The *gastric juices* of five patients were sterile (nos. 11, 14, 15, 16, and 17). One (no. 13) contained scanty *E. coli* only and the remaining juice (no. 12) scanty *Strep. faecalis* and *E. coli*.

Gastric biopsies were normal in two patients (nos. 15 and 16). Three (nos. 11, 13, and 17) showed a partial atrophic gastritis and one (no. 12) a subtotal gastric atrophy.

Jejunal juices were sterile in four patients (nos. 11, 13, 14, and 17). No. 15 contained scanty *Strep. faecalis*. The jejunal juice of no. 12 grew moderate numbers of *Strep. faecalis* and profuse *E. coli*, and this was the only patient of this group in whom both the gastric and jejunal juices yielded the same organisms and in whom a full augmented histamine test showed achlorhydria.

Jejunal biopsies demonstrated a subtotal villous atrophy in six of the seven patients and a partial villous atrophy in the seventh (no. 17).

PATIENTS WITH PERNICIOUS ANAEMIA (Table III) The eight patients with pernicious anaemia comprised five males and three females aged 39 to 79. Three patients (nos. 18, 20, and 21) were untreated at the time of investigation and the other five patients had previously received intramuscular injections of vitamin B_{12}. A full augmented histamine test was performed on all but one patient (no. 22) who had a modified histamine test meal only. No free acid could be demonstrated in the gastric juices of any of the eight patients.

Gastric cultures were sterile in only three patients (nos. 18, 19, and 20) and contained throat commensals only in one patient (no. 21). *E. coli* as well as throat commensals were isolated from the gastric juices of four patients (nos. 22 to 25). In addition lactobacilli were obtained in nos. 23 and 24 and bacteroides in no. 24.

Jejunal cultures were carried out on only five patients. Of these only one (no. 19) was sterile. In patient no. 21 throat commensals only were isolated similar to those found in her gastric juice. The remaining three patients (nos. 22, 23, and 24) grew scanty numbers of *E. coli* in the jejunal juices, and in patient no. 24 lactobacilli and bacteroides were grown in addition.

PATIENTS WITH MISCELLANEOUS DISORDERS (Table IV) There were four males and four females in this group of eight patients and their ages ranged from 21 to 64. Five of the eight patients suffered from dyspepsia which was radiologically negative in three (nos. 27, 32, and 33) and positive in two (nos. 26 and 28). The remaining three patients had disorders referable to the intestines, namely, a blind loop (no. 29), diverticulitis of the small bowel (no. 31), and chronic intermittent diarrhoea without positive findings on detailed investigation (no. 30). All but one (no. 33) had free hydrochloric acid in the gastric juice.

In four of the five patients with dyspepsia cultures of the gastric juices were sterile (nos. 26, 27, 28, and 32). In the fifth patient (no. 33) moderate numbers of *Strep. faecalis* were grown in the gastric juice in addition to moderate or profuse numbers of throat commensals. Of the three patients with intestinal disorders, the gastric juice of one (no. 31) was

TABLE IV

EIGHT PATIENTS WITH MISCELLANEOUS DISORDERS

No.	*Sex*	*Age*	*Diagnosis*	*Test*[1]	*Gastric Juice*		*Gastric Biopsy*	*Jejunal Juice Culture*	*Jejunal Biopsy*
					pH Range[2]	*Culture*			
26	M	21	Duodenal ulcer	F.A.H.	1·2–1·4	Sterile	Normal	—	—
27	F	45	*X*-ray negative dyspepsia	F.A.H.	1·6–2·0	Sterile	Normal	—	—
28	M	42	Gastric ulcer	M.A.H.	2·6	Sterile	—	Sterile	—
29	F	59	Blind loop	S.H.T.	2·4	*E. coli* +	Normal	*E. coli* +++	Normal
30	F	38	Diarrhoea of unidentified origin	S.H.T.	2·0	Commensals ++	—	Sterile	—
31	M	64	Diverticulitis of small intestine	F.A.H.	1·2–1·4	Sterile	Normal	*Strep. faecalis* + *E. coli* +++	Normal
32	M	49	*X*-ray negative dyspepsia	M.A.H.	1·3	Sterile	—	—	—
33	F	46	*X*-ray negative dyspepsia	M.A.H.	7·1	*Strep. faecalis* ++ Commensals ++	—	*Strep. faecalis* ++ Commensals ++	—

[1]F.A.H. denotes full augmented histamine test; M.A.H. modified augmented histamine test and S.H.T. submaximal histamine test (0·5 to 1·0 mg. histamine given and only one specimen of gastric juice obtained).
[2]Recorded after maximal doses of histamine (see text).

TABLE V

BACTERIOLOGICAL INVESTIGATION OF JEJUNAL BIOPSIES

Patient	Sex	Age	Diagnosis	Jejunal Biopsy Specimen		Jejunal Juice Close to Biopsy Site		Gastric Juice Culture	Jejunal Juice Culture
				Gram Stain	Culture	Gram Stain	Culture		
29	F	59	Blind loop	Scanty negative rods	Sterile	Gram-negative rods +++	*E. coli* +++ *S. faecalis* +	*E. coli* +	*E. coli* +++
33	F	46	*X*-ray negative dyspepsia	No organisms	Sterile	—	—	*S. faecalis* +++ *S. viridans* +++	*S. faecalis* ++ *S. viridans* +++
34	M	67	Polya partial gastrectomy	No organisms	Sterile	—	—	—	—
35	M	45	Idiopathic steatorrhoea	No organisms	Sterile	No organisms	Sterile	—	Sterile
36	M	49	Polya partial gastrectomy (dumping)	No organisms	*Staph. pyogenes* + *S. viridans* +	—	—	*K. aerogenes* + *Staph. pyogenes* +	—
37	M	66	Chronic pancreatitis	No organisms	*E. coli* + *K. aerogenes* ±	No organisms	*K. aerogenes* *S. faecalis* +	—	—
38	F	54	Polya partial gastrectomy (dumping)	No organisms	Sterile	—	—	—	—
39	M	62	Steatorrhoea ?cause	No organisms	Sterile	—	—	Sterile	—
40	M	55	Polya partial gastrectomy (dumping)	No organisms	Sterile	—	—	—	*E. coli* ++ *S. faecalis* +

sterile, and of the other two throat commensals only were isolated from no. 30 and scanty *E. coli* from no. 29.

Gastric biopsy was performed on only four patients (nos. 26, 27, 29, and 31) and was normal in all.

The jejunal juice was cultured in only two of the five patients with dyspepsia. It was sterile in one (no. 28) and grew moderate numbers of *Strep. faecalis* as well as throat commensals in the other (no. 33). Of the three patients with intestinal disorders, one grew profuse numbers of *E. coli* (no. 29) and one (no. 31) showed in addition to large numbers of *E. coli* a scanty growth of *Strep. faecalis*. The last patient's jejunal juice (no. 30) was sterile.

Jejunal biopsies were performed on only two patients (nos. 29 and 31) and were normal.

ADDITIONAL BACTERIOLOGICAL EXAMINATION ON NINE JEJUNAL BIOPSIES The results are given in Table V.

In the Gram-stained preparations made from the jejunal biopsy specimens, organisms were seen in only one, no. 29, a patient who had a blind loop.

Only two of the jejunal biopsy specimens yielded organisms on culture: patient no. 36, who had undergone a Polya partial gastrectomy, yielded *Staph. pyogenes* and *Strep. viridans*, and patient no. 37 with chronic pancreatitis yielded only *E. coli* and *K. aerogenes*.

In three patients (nos. 29, 35, and 37) jejunal juice was obtained at the time of the biopsy and therefore came from close to the site of the biopsy. One of these (no. 29) showed Gram-negative rods in films, and culture of it yielded *E. coli* and *Strep. faecalis*. Cultures of the juice from no. 35 were sterile and from no. 37 yielded *K. aerogenes* and *Strep. faecalis*.

The culture capsule was used to obtain gastric juice for culture in four of the patients (nos. 29, 33, 36, and 39) and of these only the last was sterile, the others yielding intestinal organisms. In addition to these, no. 33 yielded *Strep. viridans* and no. 36 *Staph. pyogenes*. Similarly, the culture capsule was used to obtain jejunal juices for culture from patients nos. 29, 33, 35, and 40. Of these, again, one only (no. 35) was sterile and the other three yielded intestinal organisms. In addition, the specimen from no. 33 yielded *Strep. viridans*.

Patient no. 29 was of interest because from her we obtained jejunal juice close to the site of the biopsy, gastric juice by capsule and jejunal juice by capsule. All three of these specimens yielded *E. coli* and the culture from the jejunal juice at the site of the biopsy yielded *Strep. faecalis* as well. In spite of this the culture of her jejunal biopsy did not yield a growth. Three of the biopsy specimens (nos. 29, 33, and 40) failed to yield organisms in spite of the fact that the cultures of the jejunal juice obtained by capsule all yielded growths.

Comparison of the cultures of the jejunal biopsy specimens and the samples of jejunal juice taken at the site of the biopsy were possible in three patients. Of these, in no. 35 both specimens were sterile; in no. 37 both specimens yielded an intestinal (though different) flora, and in no. 29 the biopsy was sterile but the juice yielded intestinal organisms.

DISCUSSION

We first analysed our results according to the *p*H of the gastric juices and Table VI shows the patients arranged in order of the most acid figure recorded for their *p*H. So arranged, they were seen to form two groups: 16 with *p*H below and 17 with *p*H above 5·0.

SIXTEEN PATIENTS WITH GASTRIC *p*H BELOW 5·0 The ages of these patients ranged from 21 to 64 with an average of just below 49. They included all but one of the patients with *x*-ray negative dyspepsia and all but one of the patients with idiopathic steatorrhoea. There were only three with partial gastrectomies. In 11 of the 16 the gastric juice was sterile on culture and when organisms did grow their growth was scanty. The jejunal juice was cultured in only 12 of the 16 patients. Seven of the 12 cultures were sterile. The organisms which grew in the remaining five jejunal juices were intestinal ones and usually numerous. One of these five patients had diverticulosis, two partial gastrectomies, one a blind loop, and one idiopathic steatorrhoea.

TABLE VI

ALL 33 PATIENTS ARRANGED IN ORDER OF THE MOST ACID OF THEIR GASTRIC JUICES

Case No.	*p*H *of Gastric Juice*	*Age*	*Condition*	*Test*	*Cultures*	
					Gastric Juice	*Jejunal Juice*
26	1·2	21	D.U.	F.A.H.	Sterile	—
16	1·2	35	I.S.	F.A.H.	Sterile	—
31	1·2	64	Jejunal resection for diverticula	F.A.H	Sterile	*E. coli* +++ *Strep. faecalis* +
32	1·3	49	*X*-ray negative dyspepsia	M.A.H.	Sterile	—
27	1·6	45	*X*-ray negative dyspepsia	F.A.H.	Sterile	—
13	1·6	52	I.S.	F.A.H.	*E. coli* +	Sterile
9	1·6	55	P.G.	M.A.H.	Sterile	*E. coli* +++
17	1·8	58	I.S.	S.H.T.	Sterile	Sterile
11	1·9	54	I.S.	F.A.H.	Sterile	Sterile
30	2·0	38	Diarrhoea ?cause	S.H.T.	Throat commensals	Sterile
8	2·0	64	P.G.	F.A.H.	Throat commensals	Sterile
29	2·4	59	Blind loop	S.H.T.	*E. coli* +	*E. coli* +++
14	2·5	57	I.S.	S.H.T.	Sterile	Sterile
28	2·6	42	G.U.	M.A.H.	Sterile	Sterile
15	4·3	38	I.S.	S.H.T.	Sterile	*Strep. faecalis* +
6	4·7	52	P.G.	F.A.H.	Proteus + *E. coli* +	*E. coli* +++
4	6·6	53	P.G.	F.A.H.	Sterile	Sterile
10	6·6	62	G.E.	F.A.H.	*K. aerogenes* +	*K. aerogenes* *E. coli* +++
7	6·9	35	P.G.	F.A.H.	Throat commensals	Sterile
33	7·1	46	*X*-ray negative	M.A.H.	*Strep faecalis* ++ Throat commensals	*Strep. faecalis* ++ Throat commensals
5	7·1	73	P.G.	F.A.H.	*E. coli* ++	*E. coli* ++
22	7·1	63	P.A.	M.A.H.	*E. coli* +++ Throat commensals	*E. coli*+
23	7·2	48	P.A.	F.A.H.	*E. coli* + Throat commensals	*E. coli* +
19	7·2	39	P.A.	F.A.H.	Sterile	Sterile
3	7·2	70	P.G.	F.A.H.	*E. coli* + Throat commensals	Sterile
21	7·3	72	P.A.	F.A.H.	Throat commensals	Throat commensals
1	7·3	54	P.G.	F.A.H.	Paracolon +	—
12	7·4	45	I.S.	F.A.H.	*E. coli* +++ *Strep faecalis* ++	*E. coli* +++ *Strep. faecalis* ++
20	7·5	79	P.A.	F.A.H.	Sterile	—
18	7·5	75	P.A.	F.A.H.	Sterile	—
25	7·6	67	P.A.	F.A.H.	*E. coli* + Throat commensals	—
2	7·6	58	P.G.	F.A.H.	Sterile	Sterile
24	7·7	56	P.A.	F.A.H.	*E. coli* + Throat commensals	*E. coli* + Throat commensals

SEVENTEEN PATIENTS WITH GASTRIC *p*H OVER 5·0 The ages of these patients ranged from 35 to 79 with an average of over 58. One had *x*-ray negative dyspepsia, one idiopathic steatorrhoea, and one had had a gastroenterostomy. Apart from them the group consisted of eight patients with pernicious anaemia and six with partial gastrectomy. Only five of the gastric juices of the patients in this group were sterile. In the remaining 12, throat commensals only were found in two, and all the 10 others showed heavy growths of faecal organisms, some with throat commensals in addition. The jejunal juices of 13 patients in this group were cultured. Five were sterile; one showed throat commensals only, and the other seven faecal organisms with or without throat commensals. The growth of the faecal organisms was usually heavy.

The gastric and jejunal flora of the two groups (as separated at *p*H 5·0) show marked differences, and this is compatible with the known effects of gastric *p*H *in vitro* on organisms, for most commensals and pathogens grow best at a neutral or slightly alkaline *p*H (7·2 to 7·6), and apart from the acidophilic bacteria, such as lactobacilli, few survive in a medium more acid than *p*H 5·0.

Compared with the results of other workers the rarity of throat commensals in our gastric and jejunal cultures is remarkable. We think that this was due to the new capsule reducing the contamination of the samples of juices with buccal flora. In the 16 patients whose gastric juices had a *p*H below 5 only two of the gastric cultures and none of the jejunal cultures yielded throat commensals. In contrast, among the 17 patients whose gastric juices had a *p*H above 5, eight of the 17 gastric cultures and three of the 13 jejunal cultures yielded throat commensals.

It is possible, if not probable, that the flora in or near the gastric and jejunal mucosae may differ widely from that in the free juices as given in Tables I-V. Paulley (1959) demonstrated Gram-positive and Gram-negative rods in the crypts of the jejunal

mucosa and overlying the surface cells in patients with idiopathic steatorrhoea but these organisms were not necessarily viable. We therefore cultured the jejunal biopsy specimens and the jejunal juices close to the biopsy sites and the ordinary specimens of gastric and jejunal juices in nine patients. The results suggest that the organisms were more numerous in the luminal juice than near or in the mucosae.

The bacteriological flora of the alimentary tract was reviewed by Cruickshank and Cruickshank in 1931. Hewetson (1904) obtained his material at operations on the stomachs of humans and also on recently killed domestic animals. Barber and Franklin (1946) took swabs directly from the mucosa and duodenum at operations for peptic ulcer and gastric carcinoma. These investigations, however, were made either on human individuals who already had some abnormality or on animals and so neither of these sources afford data about the intestinal flora of healthy humans. Direct needling of the gut at operations was then tried and had the advantage that the specimens were not contaminated by organisms from other levels of the alimentary tract but the very fact that the patient was undergoing an abdominal operation made probable if not certain an abnormality of the intestinal flora. The alternative method of obtaining specimens from healthy humans is intubation but at first it gave misleading results because the juice obtained from a desired level was not protected from contamination with organisms from other levels before, during, or after the sampling. The new culture capsule (Shiner *et al.*, 1963) was designed to overcome this contamination and so we have repeated the experiments of previous observers using the new capsule. Simultaneously with these new techniques for taking samples, the media used for the isolation of the organisms have been improved. The result is that there are now available reliable data on the distribution, species, numbers, and biochemical activities of the organisms.

The contents of the normal human stomach contain a large variety of organisms during digestion. Of these the spore-bearing aerobes are probably derived from food and the remainder of the organisms probably come from the mouth. Garrod (1939) showed that these organisms which enter the tract vary widely in their powers of survival which depend on their susceptibility to the action of hydrochloric acid. Among pathogens, for instance, shigellae are the most resistant; brucellae are very sensitive and salmonellae occupy an intermediate position. Coliform organisms are rare in the stomach and are usually confined to the species of *K. aerogenes*. Three to four hours after a meal the contents of the healthy stomach are practically sterile (Priestley, Thompson, and Sealey, 1944).

The small intestine, except for its lower few inches, yields in health very few organisms (Hewetson, 1904; Cregan, Dunlop, and Hayward, 1953; Anderson and Langford, 1958; Shiner *et al.*, 1963). This may be due to a germicidal effect in the stomach whereby ingested bacteria are killed before entering the duodenum. Seley and Colp (1941), Priestley and his colleagues (1944), and Barber and Franklin (1946) all reported a close relationship between hypochlorhydria or achlorhydria and the isolation of bacteria in gastric and duodenal juices. These results are in keeping with those of Venables and Knott (1924), who showed that in over 90% of subjects with free hydrochloric acid in the gastric juice the resting duodenal contents were sterile. Knott (1927) too found bacteria in the duodenal juice of all of 37 patients with pernicious anaemia and achlorhydria. Garrod (1939), however, concluded that gastric juice was more bactericidal than hydrochloric acid of equivalent strength and suggested causes other than the *p*H of the stomach, and Cregan and his colleagues believed that the antibacterial mechanism of the small intestine is independent of gastric secretions.

Many factors therefore influence the flora of the alimentary tract both qualitatively and quantitatively. In addition to the interval after the last meal and the *p*H of the gastric juice, they include the motility of the tract and various pathological conditions. Dixon and Paulley (1963) postulated that there was a direct relationship between the bacterial population of the small intestine and the hypomotility of malabsorption. Using rats which they injected intraperitoneally with mecamylamine to reduce the peristalsis of the small intestine, they found very large numbers of *E. coli* present in the lumen of the intestine. Bishop and Anderson (1960) too showed that stasis and small bowel obstruction favour a profuse bacterial growth.

SUMMARY

The *p*H of the gastric juice is intimately associated with both the quality and quantity of the gastrointestinal flora. We believe that it is an important but not the only factor influencing bacterial growth in the stomach and small intestine. The gastric and jejunal contents in six of 10 patients with partial gastrectomy or gastroenterostomy and four of eight patients with pernicious anaemia yielded significant growths of coliform bacilli, and such high bacterial contents were not found in either of the two other groups of patients in the present study nor in the 10 control patients of our earlier study.

Histopathological abnormalities of gastric and jejunal mucosae did not correlate with bacterial growth.

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