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Composition of the Mixed Duodenal Secretions.

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In a previous communication[1] the results of studies on the composition of mixed duodenal secretions were reported. These previous studies were performed on healed duodenal pouches completely isolated from the stomach and every effort was made to avoid all complications which might alter the composition of the mixed duodenal secretions. However, it appeared necessary to confirm these results by different methods which would be free of certain hypothetical sources of error, based primarily on the operative procedures previously employed. A large number of analyses of the contents of the dogs' stomach obtained by lavage 24 hours after a light feeding of milk and syrup have shown that under these conditions hydrochloric acid is either absent or present in very small amounts. It therefore seemed that duodenal contents obtained from the intact duodenum, 24 hours after a light feeding of milk and syrup, would be practically free from contamination by acid gastric contents. Gastrostomy openings were made low on the body of the stomach through which a duodenal tube was inserted and the tip allowed to pass into the duodenum. When the dogs were lying on the side, the main cavity of the stomach was usually below the opening into the duodenum. At frequent intervals during the experiments a small rubber catheter was passed into the stomach and an attempt made to aspirate gastric secretions. Nothing but a small amount of tenacious mucus was ever obtained. The duodenum was stimulated by introducing a standard hydrochloric acid solution (approximately one-tenth normal) containing phenol red through the duodenal tube. After a latent period of several minutes' duration a copious flow of duodenal secretions occurred. The secretions aspirated from the duodenum often contained some of the acid-phenol red solution which had been introduced but the phenol red was too dilute to determine accurately, hence the duodenal secretions were added to approximately 25 cc. of the same strength acid-phenol red solution that had been introduced into the duodenum. The samples were always bile-stained but occasionally a large

[1] Wilhelmj, C. M., Neigus, I., and Hill, F. C., *Am. J. Phys.*, 1934, **107**, 490.

amount of dark, viscid bile was suddenly added, due apparently to emptying of the gall bladder. Samples containing large amounts of gall bladder bile were usually discarded because of the difficulty in removing the bile before determining the percent of phenol red.

The following analyses were performed on the acid-phenol red solution containing the duodenal secretions: (1) The percent of phenol red after treating with two-thirds normal sulfuric acid and 10% sodium tungstate to remove mucus and bile pigments. (2) Total and mineral chloride after ashing of the dried samples.

Determination of the percent of phenol red present showed the amount of duodenal secretions that had been added to the acid-phenol red solution. The chloride concentration of the original acid-phenol red solution, when multiplied by the percent of phenol red in the mixture, corrected the original acid solution for dilution. The amount of acid chloride present after the addition of duodenal secretion was always below the corrected value due to neutralization of acid by the duodenal secretions. The total chloride present after the addition of duodenal secretions was always above the corrected value and this extra chloride was the chloride present in the duodenal secretions. Further details have been given[2] and need not be repeated here.

The results of 21 experiments performed on 3 dogs are given in detail in Table I. Two points deserve special emphasis.

1. *Chloride Concentration of the Mixed Duodenal Secretions.* The average value for 21 experiments was 307 mg. per 100 cc. and the individual values ranged from 210 to 377 mg. In the previously reported studies on isolated duodenal pouches, 19 experiments on 3 animals gave an average value of 310 mg. per 100 cc. with individual variations of approximately the same magnitude.

2. *The Alkalinity of the Mixed Duodenal Secretions.* The average value for 21 experiments was .04 normal with individual values ranging from .01 to .08 normal. In the previous studies on isolated duodenal pouches, 19 experiments averaged .04 normal with approximately the same range of variation.

The low average alkalinity of the mixed duodenal secretions is a rather surprising finding but becomes clear when it is remembered that of the 3 secretions comprising the mixed duodenal secretions (bile, *Succus entericus* and pancreatic juice) pancreatic juice is the only one which contributes definite alkalinity. The alkalinity of pure pancreatic juice according to Gamble and McIver,[3] Hartman

[2] Wilhelmj, C. M., Neigus, I., and Hill, F. C., *Am. J. Phys.*, 1933, **106**, 381.

[3] Gamble, J. L., and McIver, *J. Exp. Med.*, 1928, **48**, 837, 849.

TABLE I.

Dog	Acid Solution Used mg. Cl per 100 cc.	Total Cl mg. per 100 cc.	Mineral Cl mg. per 100 cc.	Total Minus Mineral Cl (Acid Cl)	PSP %	Cl Original Acid Solution (Corrected for Dilution)	Extra Cl mg. per 100 cc.	Cl Acid Deficit mg. per 100 cc.	Cl Concentration Duodenal Secretion mg. per 100 cc.	Cl Acid Deficit / cc. of Duodenal Secretion	Normality of Duodenal Secretions
1	350	348	103	245	81	284	64	39	336	2.1	.06
		358	89	269	79	277	81	8	386	0.4	.01
		355	93	262	82	287	68	25	377	1.4	.04
		351	75	276	85	298	53	22	353	1.5	.04
1	348	330	201	129	63	219	111	90	300	2.4	.07
		324	188	136	61	212	112	76	288	2.0	.06
		328	195	133	63	219	109	86	295	2.3	.06
2	347	342	96	246	82	284	58	38	322	2.1	.06
		331	100	231	82	284	47	53	261	2.9	.08
		336	47	289	88	306	30	17	250	1.4	.04
		342	84	258	82	284	58	26	322	1.4	.04
2	347	330	125	205	70	243	87	38	290	1.3	.04
		348	125	223	71	246	102	23	352	0.8	.02
		339	113	226	77	267	72	41	313	1.8	.05
3	352	339	54	285	82	289	50	4	278	0.2	.01
		342	50	292	86	303	39	11	278	0.8	.02
		336	44	292	89	313	23	21	210	1.9	.05
		336	46	290	86	303	33	13	236	0.9	.03
3	348	342	95	247	76	264	78	17	325	0.7	.02
		345	89	256	79	275	70	19	334	0.9	.03
		346	80	266	79	275	71	9	338	0.4	.01
Average									307	1.4	.04

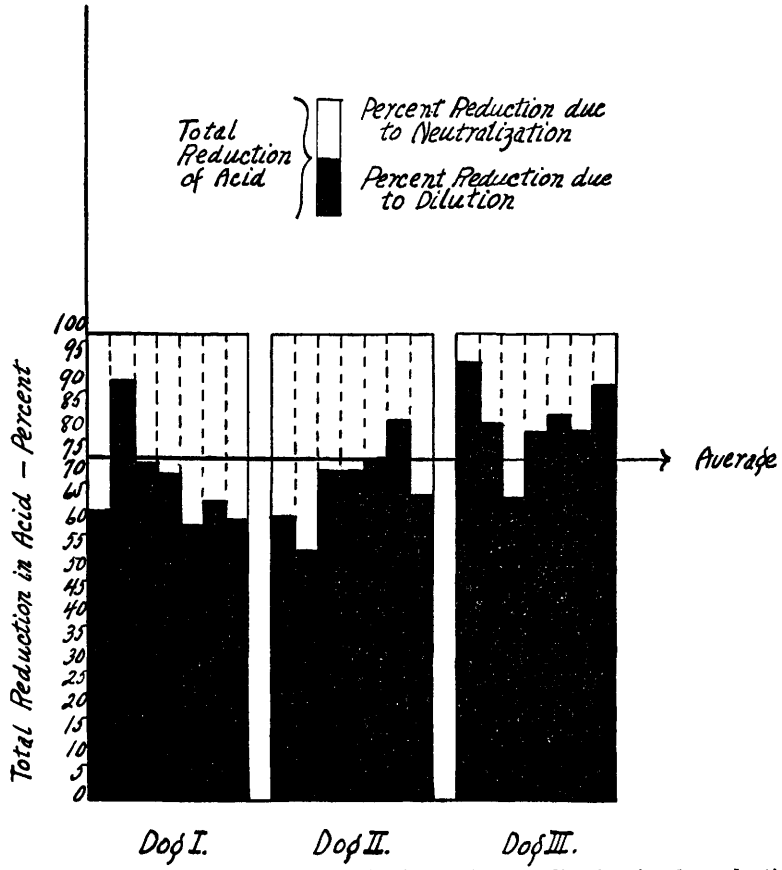
Complete data in 21 experiments in which duodenal secretions were added to approximately tenth normal hydrochloric acid solutions containing phenol red.

and Elman,[4] Elman and McCaughan,[5] and Starling[6] ranges from 0.06 to 0.1 normal. Since the relative proportion of the 3 separate secretions comprising the mixed duodenal secretions may vary in individual samples, the range of alkalinity may theoretically vary between that of *Succus entericus* and bile to a value somewhat lower than that of pancreatic juice. The average alkalinity of .04 normal indicates that in the mixed duodenal secretions the pancreatic juice is diluted by varying amounts of the nearly neutral bile and *Succus entericus,* the average dilution being approximately 50%. The average low alkalinity of the duodenal secretions makes it obvious that the effect in lowering the acidity of tenth normal hydrochloric acid depends more upon dilution than upon neutrali-

[4] Hartman, A. F., and Elman, R., *J. Exp. Med.*, 1929, **50**, 387.

[5] Elman, R., and McCaughan, J. M., *J. Exp. Med.*, 1927, **45**, 561.

[6] Starling, E. H., *Principles of Human Physiology,* Lea and Febiger, 1926.



Shows the relative importance of dilution and neutralization in the reduction of the acidity of approximately tenth normal hydrochloric acid by duodenal secretions.

zation; (Fig. 1), on the average, 73% of the reduction in acidity is due to the diluting effect and only 27% to neutralization.

The chloride concentration of mixed duodenal secretions is definitely lower than that of the secretion of the fundic portion of the stomach. When duodenal secretions regurgitate into the stomach the chloride concentration of the fundic secretion will be lowered by dilution with the duodenal secretions.

Since the chloride present in mixed duodenal secretions is neutral chloride it is obvious that when bile is present in gastric contents, the entire neutral chloride content cannot be considered as arising from neutralization of hydrochloric acid. When duodenal secretions are mixed with approximately tenth normal hydrochloric acid, only about 1.5 mg. of neutral chloride out of every 5 mg. actually represent neutralized hydrochloric acid.

Summary. The average alkalinity of the duodenal secretions was found to be approximately .04 normal and the chloride concentration 307 mg. per 100 cc. These values obtained on secretions from the intact duodenum are in excellent agreement with values previously reported on secretion obtained from isolated duodenal pouches.

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Methylene Blue as an Agent for Reducing Red Blood Cell Count.

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Over a period of a week or 10 days following intravenous injection of methylene blue into dogs poisoned with cyanide there occurs a decrease in the oxygen capacity of the blood and a corresponding decrease in red blood cell count. The same effect is observed when the dye alone is given. Results of a typical experiment are reported in this preliminary note.

Table I shows the changes in red blood cell count, oxyhemoglobin (by O_2 capacity method), and reticulocytes in a 17 kilogram dog

TABLE I.

Date	Time A.M.		Oxyhemoglobin mMols. per liter	R. B.C. in millions	Reticulocytes %
3-6-34	11:30	Blood No. 1	9.18		
	11:31	26 cc. 1% methylene blue injected			
	P.M.				
	3:20	Blood No. 2	(Methylene blue and methemoglobin not detected spectroscopically)		
	3:25	23 cc. 1% methylene blue injected			
3-10-34		Blood No. 3	3.76		
3-12-34		" " 4	2.23	1.56	1.4
3-13-34		" " 5	2.18	1.81	
3-14-34		" " 6		1.62	7.4
3-15-34		" " 7*	(White cell count only)		
3-16-34		" " 8	3.26	2.67	4.6
3-19-34		" " 9	4.63	3.36	5.2
3-21-34		" "10		3.07	3.4
3-27-34		" "11		3.82	2.0
3-29-34		" "12†	6.60	4.23	2.0

* Whites, 10,200. † Whites, 13,600.