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Medical Vagotomy: An Assessment

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Attempts have been made to predict the secretion of gastric acid after surgical vagotomy with a drainage procedure, by blocking the vagus nerves with atropine and hexamethonium or with propantheline in preoperative tests (McArthur, Tankel, and Kay, 1960; Gillespie and Kay, 1961; Checketts, Gillespie, and Kay 1966). These workers carried out two tests on their subjects before operation: the first was an augmented histamine test (Kay, 1953); in the second hexamethonium bromide 50 mg. and atropine 0.325 mg., or propantheline 30 mg., were given before the injection of histamine. If this drug-induced or "medical" vagal blockade in the second test brought about a large decrease in the response to histamine a similar large reduction in secretion was to be expected after surgical section of the vagi. On the other hand, in some patients the response to histamine was reduced by only a small amount (<35%) after medical vagotomy, and some of these subjects also had a small reduction in secretion after surgical vagotomy. It was suggested that a minority of patients with duodenal ulcer had "antral dominance" over the production of gastric acid, the vagi playing a lesser part; that it might be possible to pick them out before operation by the "medical vagotomy" test; and that they would be better treated by vagotomy and antrectomy than by vagotomy and drainage alone.

Our study is a critical examination of the above hypothesis, designed to answer the following questions: (1) Do the drugs block the vagi completely, as complete surgical vagotomy does? Does the "medical" block withstand the challenge of insulin-induced hypoglycaemia? (2) Does "medical" vagotomy provide a good forecast, for the individual patient, of the acid output he will have after complete surgical vagotomy? (3) If the forecast is accurate, what is its value?

Method

Instead of two preoperative tests, one with and one without medical vagotomy, we have used a single histamine-infusion

test (Lawrie, Smith, and Forrest, 1964), injecting atropine and hexamethonium when maximal levels of secretion have been attained after 90 to 105 minutes. The subjects were male patients with duodenal or gastric ulceration, hiatus hernia, dyspepsia without any abnormality on barium-meal examination, and normal individuals. After an overnight fast a 16 F.G. duodenal tube with a metal tip was passed transnasally into the stomach, the contents of which were aspirated by continuous suction with an electric motor. The antihistamine mepyramine maleate (Anthisan) was given in a dose of 50-100 mg. intramuscularly at the start of the test. The histamine infusion was then set up, with either a paediatric drip set or a constant-infusion pump, to deliver 0.4 µg. of histamine acid phosphate per kg. per minute intravenously throughout the test. The gastric secretion was aspirated by continuous suction, and separate samples representing 15-minute periods were collected.

After 90 to 105 minutes, when a steady rate of gastric secretion had been achieved, the medical vagotomy injection was given. Atropine sulphate 1.3 mg. (1/50 gr.) and hexamethonium bromide (C_6) 50 mg. were given together intramuscularly. Gastric secretion was then collected for a further two hours (in 74 tests) or four hours (28 tests). The "maximal" acid secretion was taken as the mean of the two or three 15-minute collections immediately before the injection of atropine and hexamethonium, while "acid output after medical vagotomy" was taken as the mean of the two or three lowest consecutive readings, which were usually recorded near the end of the test. The acidity of the samples was estimated by titration with *N*/100 NaOH, phenolphthalein being used as indicator.

Thirty-six men with duodenal ulcer underwent the above test, which lasted five to five and a half hours in 21 and three and a half hours in 15. They were then treated by vagotomy and pyloroplasty. Postoperative insulin tests (Hollander, 1948) showed the vagotomy to be complete. Seven to 14 days after operation a histamine-infusion test combined with medical vagotomy was carried out, identical in terms of drug dosage to the preoperative test, but in all cases the test ended two hours after the administration of the medical vagotomy injection, so that its total duration was about three and three-quarter hours.

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Certain points about the technique are worth mentioning. The stomach was seldom screened radiologically. For efficient recovery of the juice secreted, reliance was placed on certain stratagems evolved over many tests, such as moving the tube in or out during the test if collection diminished unexpectedly, constant personal supervision with frequent interruption of the suction and blowing of air down the tube to keep its lumen patent, asking the patient to take deep breaths (which "pump" out the gastric contents), rolling the patient on to one side then the other, and so on. While we would agree that radiological screening of the tube is ideal, we have found that even when the stomach-tube is placed "perfectly" under x-ray control it usually has to be moved at some time in the course of a long gastric test. Elevation of the foot of the bed was done routinely, after hypotension and nausea had often been seen in the early tests.

Control Studies

1. *Completeness of Medical Vagotomy as Judged by the Insulin Test.*—It was thought appropriate to subject the "medical vagotomy" to the customary test for completeness of surgical vagotomy. In three subjects atropine sulphate 0.32 mg. (1/200 gr.) and C_6 50 mg. were given intramuscularly, followed after varying intervals (see Table III) by 20 units of soluble insulin given intravenously. When a strongly positive response was elicited in each case, 14 further tests were carried out in an attempt to find a combination of drugs that would block the vagi completely. Atropine 1.3 mg. (1/50 gr.) plus hexamethonium 50 mg. were given in five tests, propantheline bromide 30 mg. intravenously in five, and, finally, C_6 plus 1.95 mg. of atropine (3/100 gr.) in four tests. The interval between the medical vagotomy injection and the insulin injection was varied, within the range 1 to 105 minutes, to ensure that in some tests at least the vagal block would not be wearing off at the time of maximal hypoglycaemia.

FIG. 1.—Showing the good correlation between acid outputs in response to histamine infusion before (P) and after medical vagotomy (M), in 21 men with duodenal ulcer.

FIG. 2.—In the same 21 patients as in Fig. 1, acid output in response to histamine infusion after complete surgical vagotomy (S) correlates significantly with the maximal response to histamine infusion before vagotomy (P).

2. *Efficiency of Recovery of Gastric Juice.*—In 12 preoperative tests two tubes were passed into the stomach, one to the usual position, while the other was 10 cm. more proximal and near the cardia. A known volume of a 0.5% or 1% solution of polyethylene glycol was gravitated at a constant rate into the stomach via the second tube during the test to find out what percentage of fluid entering the stomach was aspirated by the standard technique. Three such tests were performed postoperatively.

3. *Dose-response.*—Since we used 0.4 μ g. histamine acid phosphate/kg./min. instead of the 0.67 μ g./kg./min. stated by Lawrie *et al.* (1964) to give maximal secretory levels, the secretory responses to those two doses were compared in 12 subjects, either by tests on separate days or by giving the lower dose for six or seven 15-minute periods, then giving the larger dose for a further six to eight periods.

4. *Spontaneous Decrease in Secretion without Medical Vagotomy.*—In nine tests the histamine infusion was given for five hours without medical vagotomy, to measure the degree of spontaneous decrease in secretion over that period.

5. *Comparison of Prevagotomy and Postvagotomy Responses to Histamine.*—As a by-product of this investigation it has been possible to compare the response to histamine infusion before vagotomy (in 100 tests) and after complete vagotomy (in 52 tests); paired preoperative and postoperative responses are available for 43 subjects, 36 of whom had a complete vagotomy.

Results

Tests Lasting more than Five Hours

Surgical vagotomy was complete as judged by the insulin test in all 21 subjects. The acid output after medical vagotomy (M) was directly proportional to the original maximum acid output (P), the correlation being highly significant ($r=0.76$, $P<0.001$) (Fig. 1), and output of acid after surgical vagotomy (S) was also related in a highly significant manner to the

TABLE I.—Comparison Between the Responses to Intravenous Histamine—Alone and After Medical (Atropine + C_6) and Surgical Vagotomy

(1) Case No.	Response to Histamine—Acid Output in mEq/15 min.					
	(2) Before Vagotomy (P)	(3) After Medical Vagotomy (M)	(4) After Surgical Vagotomy (S)	(5) Difference between (3) and (4) (M - S)	(6) % Reduction after M.V.	(7) % Reduction after S.V.
1	6.8	1.7	3.6	-1.87	74.3	46.8
2	12.4	4.0	4.9	-0.89	68.0	61.0
3	8.0	2.6	1.2	+1.47	67.0	85.4
4	11.5	3.8	5.7	-1.90	67.0	50.4
5	17.0	5.9	7.5	-1.58	65.3	56.0
6	16.7	6.6	5.3	+1.33	60.4	68.4
7	18.5	7.5	9.9*	-2.41	59.7	46.7
8	20.9	9.1	11.3*	-2.23	56.6	45.9
9	9.3	4.1	2.6	+1.53	56.0	72.0
10	8.6	4.0	1.0	+3.04	53.6	89.0
11	8.7	4.2	1.8	+2.40	52.2	79.6
12	14.9	7.4	7.4	0	50.8	50.8
13	13.9	7.3	6.1	+1.18	47.5	56.1
14	16.6	8.8	4.9	+3.90	47.1	70.7
15	9.9	5.5	6.8	-1.36	45.0	31.3†
16	10.0	6.0	4.7	+1.33	40.0	53.0
17	14.8	9.0	12.7*	-3.68	39.3	14.5‡
18	12.0	7.3	3.9	+3.39	39.2	67.4
19	18.5	11.4	11.0*	+0.37	38.5	40.5
20	12.6	9.1	5.9	+3.17	27.6†	52.8
21	10.0	7.3	5.2	+2.14	26.6†	48.0
Mean	12.93	6.31	5.86	+0.44	51.51	56.47

* These acid outputs might be regarded as "too high" postoperatively (all 21 surgical vagotomies were complete).

† These percentage reductions with medical vagotomy seem "inadequate," yet the results of surgical vagotomy appear satisfactory.

‡ These small reductions in secretion after surgical vagotomy were not predicted by medical vagotomy.

Statistical Analysis:

Correlation coefficient between acid outputs after M.V. and S.V. (columns 3 and 4), $r=0.73$, $P<0.001$.

Mean and standard error of difference between M and S (column 5) = $+0.44 \pm 0.5$.

Correlation coefficient between outputs after histamine (P) and M.V. (M), $r=0.76$, $P<0.001$.

Correlation coefficient between outputs after histamine (P) and S.V. (S), $r=0.81$, $P<0.001$.

preoperative maximal acid output ($r=0.81$, $P<0.001$) (Fig. 2). The regression of M on P is given by the equation $M=0.47P+0.21$ and that of S on P by the equation $S=0.64P-2.38$. There was a highly significant correlation between the acid output after medical vagotomy (M) and that after surgical vagotomy (S) ($r=0.73$, $P<0.001$). The regression of S on M is given by the equation $S=0.96M-0.18$, and the mean difference between M and S was $0.44 \text{ mEq/15 min.} \pm \text{S.E. } 0.50$. Since the preoperative response to histamine (P) gave the best correlation with the acid output (S) after vagotomy, the predicted output after vagotomy—derived from the equation $S=0.64P-2.38$ —was calculated and compared with the actual output after surgical vagotomy (see Table II, where a similar comparison between predicted and actual acid outputs after vagotomy has been calculated from the data of Checketts *et al.*, 1966).

Details of the results for each individual patient (Tables I and II) show that in the individual case, as might be expected, the prediction of postoperative secretion provided by the preoperative medical vagotomy was unimpressive; subjects 20 and 21, who had only small reductions in secretion after medical vagotomy, had near-average reductions after surgical vagotomy, while the two subjects (Nos. 15 and 17) who had reductions in secretion of only 31% and 15% respectively after surgical vagotomy had not been picked out by the preoperative medical vagotomy. Again, four subjects (Nos. 7, 8, 17, and 19) still had very high levels of secretion ($>9 \text{ mEq/15 min.}$) after vagotomy, yet in only one case (No. 19) had this result been forecast preoperatively.

Tests Lasting Three and a Half Hours

The detailed results in this group of subjects do not merit such close scrutiny, because even as late as two hours after the injection of atropine and hexamethonium gastric secretion has not stabilized at its new low "plateau"—it continues to decrease for a further hour, as is readily seen in Fig. 3. In the previous group of 21 individual prediction was poor; in this group it was completely valueless.

The mean acid output in response to the infusion of histamine in the 36 male patients with duodenal ulcer was $12.54 \text{ mEq/15 min.}$ preoperatively. Medical vagotomy brought about a mean reduction of 51.5% in the group of 21 tests, the mean output being 6.31 mEq/15 min. , while in the 36 subjects surgical vagotomy caused a mean reduction of 55.6% and the mean output was 5.68 mEq in 15 minutes.

Control Studies

1. *Completeness of Vagal Block.*—The vagal block was complete in only 2 of the 17 tests in which it was challenged with intravenous insulin (Table III). The complete block was found in two of four tests in which the very large dose of atropine, 1.95 mg. (3/100 gr.), was given in conjunction with 50 mg. of hexamethonium. The block produced by atropine 0.33 mg. or 1.3 mg., together with hexamethonium 50 mg., and that produced by propantheline 30 mg., did not prevent the

FIG. 3.—In the nine control histamine infusions the small spontaneous decrease in secretion after 90 minutes contrasts with the marked inhibition brought about by the medical vagotomy in the 28 tests.

gastric secretory response to insulin. Significant increase in the concentration of gastric acid took place within one hour of injecting insulin in six tests, and in the second hour in the remaining nine.

2. *Efficiency of Recovery of Gastric Contents.*—In 12 tests before operation 92% of the polyethylene glycol infused into the stomach was recovered (range: 79–100%); in three tests after operation recovery was 90%, 85%, and 86%.

3. *Dose-response.*—In eight tests $0.4 \mu\text{g./kg./min.}$ histamine acid phosphate elicited an acid output 97.8% of that elicited by $0.67 \mu\text{g./kg./min.}$ (range: 88–112%).

4. *Spontaneous Decrease in Secretion.*—In the nine control histamine infusions in which the injection of atropine and hexamethonium was omitted a mean spontaneous decrease of 15.7% compared with the maximal levels had occurred after five hours (Fig. 3) (range: 50% decrease to 26% increase). Even after complete surgical vagotomy the medical vagotomy

TABLE II.—Comparison Between Predicted and Actual Acid Outputs After Surgical Vagotomy (S.V.)

Case No.	A. Present Series Acid Output in mEq/15 min.				B. Data Calculated from Series of Checketts <i>et al.</i> (1966) Acid Output in mEq/30 min.		
	(1) Maximum Acid Output in Response to Histamine before Vagotomy P	(2) Predicted Output after S.V., from Equation $S=0.64P-2.38$ S (Predicted)	(3) Actual Output after S.V. S (Actual)	% Error of Prediction	Predicted Output after S.V. from Computer-derived Formula	Actual Output after S.V.	% Error of Prediction
1	6.8	2.0	3.6	44.4	4.3	6.1	29.5
2	12.4	5.6	4.9	14.3	1.5	3.2	53.1
3	8.0	2.7	1.2	125.0	11.9	10.6	12.3
4	11.5	5.0	5.7	12.3	6.6	8.5	22.4
5	17.0	8.5	7.5	13.3	8.9	3.7	140.6
6	16.7	8.3	5.3	56.6	4.9	2.9	69.0
7	18.5	9.5	9.9	4.0	2.9	3.7	21.6
8	20.9	11.0	11.3	2.7	10.3	9.6	7.3
9	9.3	3.6	2.6	38.4	3.8	0.5	(660.0)
10	8.6	3.1	1.0	(210.0)	7.8	6.4	21.9
11	8.7	3.2	1.8	77.8	5.7	4.7	21.3
12	14.9	7.2	7.4	2.7	0.7	1.2	(41.7)
13	13.9	6.5	6.1	6.6	6.5	5.9	10.2
14	16.6	8.2	4.9	67.4	7.8	9.8	20.4
15	9.9	4.0	6.8	41.2	3.6	3.8	5.3
16	10.0	4.0	4.7	14.9	8.2	9.3	11.8
17	14.8	7.1	12.7	44.1	-2.1	1.5	(240.0)
18	12.0	5.3	3.9	35.9	6.4	6.1	4.9
19	18.5	9.5	11.0	13.6	3.8	8.7	1.53
20	12.6	5.7	5.9	3.4	6.9	3.7	86.5
21	10.0	4.0	5.2	23.1			
Mean error	..		(20) 32.09%			(17) 34.95%	

In the four cases where the percentage error has been excluded from calculation of the mean error, actual acid output after surgical vagotomy was very low (2 mEq/30 min.). These data highlight the large errors which may occur in prediction for the individual, despite high statistical accuracy of the prediction for the group as a whole.

injection caused a prompt decrease in acid secretion, which was maintained, but this decrease was not statistically significant. After incomplete vagotomy (late positive tests) medical vagotomy in six subjects produced no greater decrease in acid output than it did in the completely vagotomized subjects.

5. *Prevagotomy and Postvagotomy Histamine Responses.*—Mean figures for 52 histamine infusions after complete vagotomy and 100 before vagotomy (Fig. 4) show that the

FIG. 4.—The similarity in the pattern of response to histamine infusion before and after vagotomy is shown. After vagotomy, peak levels of secretion are reached 15 minutes later. The numerals denote the number of tests: note that the number of tests was diminished in the last 15-minute period.

response to histamine was slightly slower after vagotomy, peak secretion being attained in the sixth 15-minute period rather than in the fifth.

Discussion

This study was designed to answer three questions.

1. Do the drugs block the vagi completely? We have found that medical vagotomy, as used at present, is an incomplete vagotomy. This statement applies both to the vagal block brought about by hexamethonium and atropine in combination and to that caused by propantheline, for in neither instance did the block prevent significant increase in gastric acid secretion in response to insulin-hypoglycaemia. There can be no doubt that the agents used were potent, because the tachycardia and dry mouth commented on by Checketts *et al.* (1966) were always produced. Since the vagal block was not complete, the test could provide an accurate prediction, for the individual patients, of the acid secretion to be expected after

a complete surgical vagotomy only if the block produced was a constant percentage of total vagal activity.

2. Does medical vagotomy provide a good forecast for the individual? As in other series (Gillespie and Kay, 1961; Checketts *et al.*, 1966), a good correlation was found between the acid outputs after medical and surgical vagotomy (correlation coefficient 0.73). Despite this, a substantial number of patients have a sufficiently large error to invalidate the prediction, which in about one-quarter of the tests might have been misleading. At present it is difficult to see how a prediction with this possibility of error could be used as an index to decide when a surgical vagotomy plus a drainage procedure would not be adequate treatment for duodenal ulceration.

A simple and accurate assessment of the effect of surgical vagotomy can be obtained by considering acid output in response to intravenous histamine, without using the results of medical vagotomy. A high degree of correlation was found between this acid output (P) and that after surgical vagotomy (S) (correlation coefficient 0.81; Fig. 2). With the linear regression equation ($S = 0.64P - 2.38$), a prediction was made of the effect of surgical vagotomy and compared with the actual results. The accuracy of this prediction was similar to that obtained by Checketts *et al.* (1966). There was a mean percentage error of 32% compared with 35% in their series (Table II). It is clear that this prediction again may fall down in the individual case.

3. If the forecast were accurate, what would be its value? An even more fundamental objection to the idea of performing medical vagotomy as a preoperative routine is the consideration that a prediction of postoperative acid output, even if of unerring accuracy, would probably be of limited value in any case, because recurrent ulceration appears to be determined much more by the completeness or otherwise of the vagotomy than by any arbitrary level of acid secretion after operation. Holt and Lythgoe (1961) and Clark, Murray, Slessor, and Wyllie (1964) conclude, from a follow-up of 100 patients for ten years and of 146 patients for two to five years respectively after vagotomy, that recurrent ulceration is not predisposed to by high levels of acid secretion before vagotomy, provided that the latter is complete. These authors seem to have disproved the contention of Bruce, Card, Marks, and Sircus (1959) that partial gastrectomy plus vagotomy is needed for the hypersecretors. While 10% is a commonly quoted figure for the incidence of recurrent ulceration after vagotomy and drainage operations (Sircus and Small, 1964), the 100 subjects providing this 10% recurrence rate are likely to include 30 whose vagotomy is incomplete as judged by the insulin test (Smithwick, 1958; Ross and Kay, 1964; Borge, 1964). Where

TABLE III.—*Insulin Challenge to "Medical" Vagal Block in Subjects with Intact Vagi*

	Test No.	Time between M.V. and Injection of Insulin (min.)	Dose of Soluble Insulin i.v. (units)	Acid Output mEq/30 min.			Grading of Response to Insulin.* Negative, or Early or Late Positive according to Change in Acid Concentration
				Spon-taneous	At Peak after Insulin	% Increase	
Group I. Atropine 0.33 mg. + hexamethonium 50 mg. i.m.	1	105	20	1.58	6.57	315.8	Early positive
	2	75	20	1.05	6.50	519.0	Late positive
	3	90	20	0.95	4.43	366.3	" "
	4	75	16	0.62	4.77	669.4	" "
Group II. Atropine 1.3 mg. + hexamethonium 50 mg. i.m.	5	60	16	1.76	8.03	356.3	Early positive
	6	60	16	1.16	12.53	980.2	Late positive
	7	60	16	3.60	10.44	190.0	Early positive
	8	60	16	2.10	19.90	847.6	" "
Group III. Atropine 1.95 mg. + hexamethonium 50 mg. i.m.	9	60	20	0.69	0.56	-18.8	Negative
	10	60	20	0.42	0.13	-69.0	" "
	11	60	20	1.76	12.43	606.3	Late positive
	12	60	20	0.30	1.26	320.0	Early positive
Group IV. Propantheline 30 mg. i.v.	13	1	12	0.50	13.73	2,646.0	Late positive
	14	5	12	1.56	9.52	510.3	" "
	15	15	12	3.00	7.40	146.7	Early positive
	16	40	12	0.38	2.37	523.7	Late positive
	17	60	16	2.33	3.33	42.9	" "
Mean (excluding 9 and 10)						602.3%	

Hollander's (1948) criteria for a positive insulin test were applied. * Early positive means an increase in concentration of acid of 20 mEq/l. in the first hour after insulin, or 10 mEq/l. if the basal specimens were anacid. Late positive signifies a similar increase in the second hour. This is a slight modification of the criteria used by Ross and Kay (1964). In tests 1, 2, and 3 mepyramine maleate 100 mg. was given 60, 30, and 60 min. respectively after the medical vagotomy. The subjects were normal individuals and patients with duodenal or gastric ulcer.

the rate of incomplete vagotomy is much lower than the average, the incidence of recurrent ulcer is no higher than that after partial gastrectomy. Holt and Lythgoe (1961), for example, were able to report an incidence of 1% recurrent ulceration in 100 subjects with vagotomy and gastrojejunostomy followed up for ten years, and MacKelvie (1963) had a similar incidence in a large series of vagotomies.

The existence of a distinct group of patients with "antral dominance" over acid secretion has yet to be proved; if it does exist it seems to account for only a small percentage of all recurrent ulcers. The experience of recurrent ulcer in Sheffield shows that its incidence is about 2% among those whose vagotomy has been complete, 25% in those with a late-positive insulin test, and not less than 50% in those whose insulin test is positive in the first hour after insulin. These results are in accord with those of Weinberg, Stempien, Movius, and Dagradi (1956), who, in a careful follow-up, over two to six years, of 200 patients treated by vagotomy, found that recurrent ulceration was nearly always due to incomplete vagotomy, as demonstrated by the insulin test. In their paper on medical vagotomy Gillespie and Kay (1961) found that 13 out of 36 subjects (36%) seemed to have antral dominance in the pre-operative test. If it were accepted that about one-third of any 100 patients with duodenal ulcer coming to operation required antrectomy in addition to vagotomy, a mortality rate of nearly 2% would be likely to follow instead of the 1% associated with vagotomy and a drainage procedure. This doubling of the risk seems unnecessary when complete vagotomy combined with effective gastric drainage virtually guarantees immunity from recurrent ulceration.

The distress caused to the patients should not be forgotten. The tests are not pleasant. Before operation, either two tests each lasting about three hours must be performed on separate days or a single protracted one lasting five and a half hours. Many women were very distressed, and we stopped doing routine tests on women. Morbidity was low, but hypotensive episodes still had to be guarded against when the subject stood up: faintness, vomiting, and retching occurred occasionally, and one old man developed acute retention of urine.

To pass on from discussion of the central theme, certain minor issues can be dismissed briefly.

Recovery of 92% of the juice secreted in the preoperative tests and of 87% postoperatively is comparable with the findings of Rovelstad (1963) and implies that any error due to losses through the pylorus is small.

In eight subjects the dose of histamine used in this study elicited an acid output 97.8% of that elicited by the larger dose used by Lawrie *et al.* (1964) (range: 88–112%). The mean acid output in 36 men with duodenal ulcer was 12.54 mEq/15 min., which is as high as any quoted in the literature for this condition. Thus maximum levels of secretion were elicited and reductions obtained after medical and surgical vagotomy which are almost identical with those recorded by Christiansen and Køster (1965), who used larger doses of histamine by infusion and a medical vagotomy consisting of 50 mg. of hexamethonium and 0.3 mg. of atropine sulphate.

Benn, Daly, and Williams (1965) have suggested that the rate of increase of gastric acid secretion in response to intra-

venous histamine was slower after vagotomy than before vagotomy, and that this change in the character of the response might be of value in showing that the vagotomy had been complete. It was suggested that the histamine infusion test might provide an alternative to the insulin test while at the same time providing valuable information about the maximal acid output after vagotomy. We have found (Fig. 4) that the change in rate of gastric response to histamine brought about by complete vagotomy is small, and we doubt whether the configuration of the postvagotomy response would enable one to make valid deductions about the completeness or otherwise of the vagotomy.

Summary

In men with duodenal ulcer a comparison has been made between the effect of hexamethonium and atropine, and of complete surgical vagotomy and pyloroplasty, on the gastric acid response to a histamine-infusion test.

The existence of statistically significant correlation between the acid outputs after medical and surgical vagotomy was confirmed when the preoperative and postoperative groups were compared.

For the individual patient, however, preoperative medical vagotomy did not provide a good prediction of acid secretion after complete surgical vagotomy. Medical vagotomy as used at present was found to be an incomplete vagotomy as judged by the insulin test, and the degree of vagal block seemed to vary; this may explain the poor predictive value of the test for the individual. The value of any prediction, however accurate, of the acid output after vagotomy is questioned, since recurrent ulcer is usually attributable to incomplete vagotomy, not to high levels of secretion *per se*. The tests are tedious and unpleasant and occasionally cause faintness, vomiting, or headache. We suggest that "medical vagotomy," as used at present, is not worth using in the preoperative assessment of patients with duodenal ulcer.

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