

Long Term Results of Gastrectomy with Respect to Blood Lipids, Blood Pressure, Weight and Living Habits

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A sample of ambulant Japanese-American men (ages 45–69 years), was divided into those having a previous partial gastrectomy and a control non-gastrectomy population. Three-hundred-and-forty-seven men with a history of partial gastrectomy weighed less and had lower values for serum cholesterol, triglyceride, and blood pressure than did the control population of 7,598 men. The depressed lipid and blood pressure values could not be entirely explained by the reduced weight. Likewise, none of these differences appeared related to diet or living habits. Those operated on for gastric ulcer had, on the average, lower systolic pressures than duodenal ulcer patients and those with gastrojejunal anastomoses had lower cholesterol levels than patients with a gastroduodenostomy.

THE PATHOPHYSIOLOGICAL SEQUELAE of partial gastrectomy include weight loss, anemia, fat malabsorption, and abnormalities of bone and carbohydrate metabolism.^{3,4,7,9–11,13,16–18,22,25–28,33} The pathogenesis of these sequelae is complex, involving potentially interacting factors such as the type of surgery and living habits of the patient. In general, followup studies of gastrectomy have given an incomplete picture of the extent to which patients differ from normal populations in terms of diet, physical activity, alcohol ingestion and smoking, either because they have focused on symptomatic individuals or because they have been based in

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surgical referral centers where it is often difficult to obtain a truly appropriate control group.

We have examined a general population of Japanese-American men in Honolulu. Those who had undergone partial gastrectomy for benign disease were identified and, in this first report, are compared to the rest of the cohort with respect to selected physiologic variables and living habits. Patients from all of the major community hospitals in and around Honolulu are included so that these data should reasonably represent some of the adjustments made by average patients over the long term. In addition, we have separately analyzed the results by location of ulcer, type of anastomosis, and extent of gastric resection.

Methods

The Honolulu Heart Study is following a cohort of men of Japanese ancestry born between 1900 and 1919, who were non-institutionalized residents of Oahu in 1965. Their names were obtained through 1940–42 Selective Service Registration records. Of 11,148 men who were located, 9,878 answered mailed questionnaires, and 8,006 of these men were examined between 1965 and 1968.³⁴

The men were questioned specifically about any past history of gastric surgery, and an attempt was made to review the hospital records for each of the positive responses. Excluded from analysis were cases in which the hospital records could not be located, the diagnosis was malignancy, or no gastric tissue was removed. In order

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to obviate the acute effects of surgery, cases having gastric resection within one year prior to examination were also excluded. The 7,598 subjects who gave no history of gastric surgery comprised the control population.

The following physical variables were measured during the examination: weight, height, subscapular skin fold thickness, and blood pressure. Dietary history was elicited by a registered dietician using a 24-hour recall method.²⁹ Basic demographic data and usual habits with regard to physical activity, alcohol, and tobacco were ascertained. Nonfasting blood was taken for determination of hematocrit, cholesterol, and triglyceride.² Weight estimates for the years 1940–42 were obtained from the Selective Service records.

In the following analysis we have made considerable use of age-adjusted means because they are a convenient way of summarizing the data. Differences limited to one part of the age spectrum can be obscured by such summary statistics, but the significant differences reported here appear to reflect trends across the whole (45–69) age span. Age adjustments were done in 5-year age groups using the whole population as the standard. T-tests on the age-adjusted means were carried out according to Armitage.¹

Results

Of the 8,006 examined men, 347 qualified for inclusion in the study as partial gastrectomy subjects. The number of years between surgery and the examination varied from one to 32 years, the mean being 7.3 years. A breakdown by diagnosis and type of surgery is given in Table 1. Of these men, 33.7% were operated for duodenal ulcer, 58.2% for gastric ulcer, 4.3% for combined duodenal and gastric ulcers, 3.2% for hemorrhagic gastritis and in only 0.6% was the diagnosis not determined. A gastroduodenal anastomosis was done in 171 (49.3%) and 169 (48.7%) had gastrojejunal anastomoses. The exact type of reconstruction could not be determined from the records in 7 of the 347 patients.

Of the total surgical group, 18.2% had a vagotomy performed as well. The presence or absence of vagotomy could not be ascertained in 16 cases (4.6%).¹ Sufficient information to evaluate the amount of stomach removed was available in 234 (67.4%) of the patients. Within this group, 76.7% had at least half of their stomach removed and 41.0% had two-thirds or more removed.

The educational background of the surgical group is very similar to the general population (Table 2). Small differences in occupation were noted, the partial gastrectomy group being slightly under-represented among the skilled workers, foremen, and managerial groups, and slightly over-represented among the unskilled workers

TABLE 1. *Partial Gastrectomy Patients by Underlying Disease, Type of Anastomosis, and Extent of Resection*

Site of Anastomosis	Amount of Stomach Resected	Gastric Ulcer	Duodenal Ulcer	Other, Combined and Unknown	Total
Duodenum	All cases	124	35	12	171
	<2/3	60	18	5	83
	≥2/3	34	8	3	45
	Unknown	30	9	4	43
Jejunum	All cases	76	78	15	169
	<2/3	27	26	2	55
	≥2/3	18	26	7	51
	Unknown	31	26	6	63
Unknown	Unknown	2	4	1	7
Total		202	117	28	347

and clerks. Age-adjusted comparisons of certain physical and biochemical attributes between the gastrectomy subjects and the control population are shown in Table 3. The mean weights were quite similar in 1940–42, but, subsequently, the control population gained an average of 10.5 pounds, whereas the mean weight of the gastrectomy men was similar to that recorded in 1940–42. There was a statistically, but not clinically, significant difference for hematocrit between the two groups. Cholesterol, triglycerides and both systolic and diastolic blood pressures were lower in the gastrectomy group. No difference in the index of physical activity was demonstrated in the univariate analysis.

The intake of the various nutrients tabulated was almost identical in the two groups (Table 4). The gastrectomy subjects consumed more caffeine on the average than did the controls. Analysis of the types of alcoholic beverages showed that the surgical subjects tended to drink more beer and less liquor than did the controls

TABLE 2. *Education and Occupation Among Men With and Without a Partial Gastrectomy*

	Gastrectomy Subjects		Normal Population	
	N	%	N	%
Highest Educational Level				
Primary school	18	5.2	462	6.1
Junior high school	163	47.0	3392	44.7
Senior high school	126	36.3	2635	34.7
Technical school or university	40	11.5	1107	14.6
Present Occupation				
Unskilled and semi-skilled workers	64	18.4	1128	14.8
Skilled workers and foremen	140	40.3	3756	49.4
Clerical and sales workers	75	21.6	1330	17.5
Managerial and professional men	23	6.6	698	9.2
Farmers, retired, unemployed, and other men	45	13.0	687	9.0

TABLE 3. *Attributes of Normal Men and of Gastrectomy Subjects by Ulcer Location and by Type of Anastomosis (Age-Adjusted Means)*

	Normal Population (7598)	All Gastrectomy Subjects (347)	Gastrectomy Subjects Only			
			Ulcer Location		Anastomosis	
			Gastric (202)	Duodenal (117)	Duodenum (171)	Jejunum (169)
Height (in)	64.1*	64.4	64.3	64.5	64.2	64.6
Weight in 1940-1942 (lb)	129.6	130.0	129.4	130.9	129.1	131.1
Weight in 1965-1968 (lb)	140.1†	129.6	128.6	130.6	128.2	130.6
Back skinfold (mm)	16.7†	13.2	12.8	13.6	12.9	13.2
Hematocrit (%)	44.7†	44.0	43.8	44.4	44.3	43.8
Serum cholesterol (mg%)	219.1†	204.4	204.3	205.4	208.8*	199.4
Serum triglyceride (mg%)	233.0†	189.3	187.4	185.5	196.2	184.2
Systolic blood pressure (mmHg)	137.3†	131.4	128.7*	135.1	132.2	130.8
Diastolic blood pressure (mmHg)	82.9†	77.7	77.2	78.2	78.4	77.2
Cigarettes per day†	10.1†	14.4	15.9*	12.3	14.3	14.7
Physical activity index	32.8	32.5	32.5	32.7	32.8	32.0

Asterisks and daggers indicate significant differences (by t-test) between the two adjacent age-adjusted means. * $p < .05$ † $p < .001$

† Includes non-smokers.

Figures in parentheses indicate number of men tabulated.

(Table 4), although the total intake of alcohol did not differ between the two groups. Of the gastrectomy group, 61.1% were cigarette smokers at the time of the Honolulu Heart Study examination; 26.5% were past smokers and 12.4% had never smoked. This compares to 42.6%, 25.9%, and 31.5% respectively, in the control population. Among the smokers, there was no difference in average number of cigarettes smoked per day between the surgical and control groups.

Two tests of the statistical independence of these findings were carried out. First, since systolic and diastolic blood pressure, cholesterol, and triglycerides are known to be correlates of obesity, a weight, height and age-matched control group of 347 men was selected from the larger non-operated population. Comparing the gastrectomy subjects with this control group, all four of the lipid and blood pressure differences persisted at a significant level. Second, the interdependence of the many variables included in Tables 3 and 4 was analyzed by a discriminant analysis (Table 5). This is a reasonably satisfactory statistical procedure for deciding if a given variable still differs significantly between two groups of subjects after taking other variables into account.⁵ The significant t-values in the table suggest that the differences in cholesterol and diastolic blood pressure between gastrectomy and non-gastrectomy subjects persist even after adjusting for age, height, weight change, and alcohol and tobacco habits. The difference in triglyceride is not significant when its association with cholesterol is taken into account; nor is the difference in systolic blood pressure significant after accounting for its correlation with the diastolic pressure. It is of interest that the slightly greater physical activity of the control group becomes significant in the multivariate setting.

Univariate and multivariate analyses were carried out to ascertain whether the site of ulcer, type of anastomosis at surgery, proportion of stomach removed, presence or absence of vagotomy, or number of years since surgery had any major effect on the physiologic variables under consideration. No such effects could be demonstrated for vagotomy or for elapsed time since surgery. However, differences by ulcer site and type of anastomosis were noted (Tables 3 and 4). The gastric ulcer patients were found to have lower systolic blood pressures than the duodenal ulcer patients. No difference in weight was found which could account for this. Comparison between the duodenal and jejunal anastomoses revealed lower cholesterol levels among those with gastrojejunostomy, which could not be explained in terms of dietary or body weight differences.

Those with more than two-thirds of their stomachs resected weighed less than did men with smaller resections, but the difference was not statistically significant (Table 6). There appeared to be no important differences in any of the other physiologic variables, but the men with larger resections smoked significantly less and ate less fat than the others. Not shown in the table are drinking habits which did not differ significantly between the two groups.

Discussion

In general, the subjects for the entire Honolulu Heart Study tended to be asymptomatic as illness was found to be one reason for not volunteering for the project.³⁴ This same selection process appeared to apply to the surgical patients as it was our clinical impression that they had very little in the way of "dumping" symptoms.

TABLE 4. *Intakes of Selected Nutrients and Alcoholic Beverages for Normal Men and for Gastrectomy Subjects by Ulcer Location and by Type of Anastomosis (Age-Adjusted Means)*

	Gastrectomy Subjects Only					
	Normal Population (7598)	All Gastrectomy Subjects (347)	Ulcer Location		Anastomosis	
			Gastric (202)	Duodenal (117)	Duodenum (171)	Jejunum (169)
24 Hour Recall Data						
No. of Meals and Snacks	4.8	5.2	5.2	5.2	5.2	5.3
Calories	2270	2290	2330	2240	2230	2340
Protein (gm)	94.0	92.9	92.6	94.2	90.7	95.0
Total Fat (gm)	85.2	83.5	85.5	81.7	82.6	83.5
Saturated Fatty Acids (gm)	31.4	30.8	31.2	30.6	30.4	30.9
Polyunsaturated Fatty Acids (gm)	15.3	15.0	15.5	14.3	15.0	14.6
Total Carbohydrate (gm)	260	265	271	253	261	268
Cholesterol (mg)	545	558	562	552	549	562
Alcohol (gm)	13.2	15.6	14.8	17.0	12.0	19.0
Caffeine (mg)	437*	482	495	470	470	499
Usual Intake of:						
Beer (oz/mo)†	251†	370	409	308	298	429
Wine (oz/mo)†	9.0	8.2	10.8	6.2	10.3	6.7
Liquor (oz/mo)‡	9.3†	5.0	3.8	6.0	2.5*	7.5

Asterisks indicate significant differences (by t-test) between the two adjacent age-adjusted means. *p < .05 †p < .001

‡ Includes non-drinkers.

Figures in parentheses indicate number of men tabulated.

Indeed, despite their underlying ulcer disease and subsequent surgery, the gastrectomy individuals did not differ from the general population with respect to physical activity or ingestion of the major nutrients.

However, even with these similarities and lack of symptoms, the partially gastrectomized men weighed less and had lower blood pressure and serum lipids than the general population. The highly significant difference in skin fold thickness suggests that the low weight was due primarily to the absence of excess fat, though some reduction in lean body mass could not be ruled out. Seventy-one per cent of the men had a weight below the median for the general population.

Postlethwait *et al.*²⁵ and Wheldon *et al.*³² have emphasized that the most important etiologic factor in the weight loss is diminished caloric intake. However, as there were no dietary differences between cases and controls, the reduction of weight in the surgical cases in this population would appear to be due to malabsorption of the ingested nutrients. The lower serum cholesterol among the men with a gastrojejunostomy is consistent with malabsorption as this anastomosis is more often associated with disturbances of lipid absorption than is gastroduodenostomy.^{19,31} The persistence of lower lipid levels in the gastrectomy patients even after controlling for weight and diet is also suggestive of malabsorption.

Low blood pressures in peptic ulcer patients have been described,^{14,21} but the reports did not state what proportion of their cases had had a partial gastrectomy. Therefore, the underlying ulcer diathesis (especially gas-

tric ulcer) may account for the weight adjusted blood pressure differences between the gastrectomy cases and the normal population. The higher blood pressure in the controls is not expected on the basis of their greater skin fold thickness, since the association of blood pressure with obesity has been shown not to be an artifact due to arm circumference.²⁴ The lower systolic blood pressures in gastric ulcer cases compared to duodenal ulcers, to our knowledge, has not been previously reported.

A greater proportion of the gastrectomy individuals smoked than did individuals in the control population. An association has been shown between smoking and peptic ulcer diseases,^{8,30} but it is not clear as to whether this relationship is causal in nature or indirect. The substantial difference in cigarette smoking between the operated and non-operated men raises the issue of whether the decreased weight, lipid and blood pressures found in our study might be attributable to the cigarette habit. The multivariate analysis (Table 5) suggests that this was not the case. Nevertheless, smoking differences need to be taken into account in studying the effects of gastrectomy, since smoking probably influences weight change²³ and blood pressure.^{6,15} The multivariate analysis also suggests that caffeine had no direct effect on the physiologic variables. The greater consumption of caffeine in the surgical group was probably correlated with cigarette smoking.

Anemia can occur in patients with gastrectomy,^{17,22} but, in the present data, the overall difference in hematocrit was small. In fact, none of the gastrectomy individuals had a hematocrit less than 35%. However, the small

TABLE 5. *Physical, Chemical, Dietary, and Habitual Factors^a Related to Gastrectomy Status in a Stepwise Discriminant Analysis*

Independent Variables	Significance Level (t-test)
Weight Change	.001
Height	.001
Serum Cholesterol	.001
Diastolic Blood Pressure	.001
No. of Cigarettes/Day	.001
Weight 1965-1968	.001
Beer Consumption	.001
Liquor Consumption	.01
Physical Activity Index	.01
Caffeine Intake	—†
Age	—†
Serum Triglyceride	—†

* The original analysis on which this table is based was carried out using age(yrs) plus all the variables listed in Tables 3 and 4 except for number of meals and snacks. In addition, the weight change between 1940-42 and 1965-68 was included. All variables which significantly ($p < .05$) reduced the variance when added to the linear function are listed here.

† Variable included because it was felt to be of particular interest, though it made no significant contribution to the discrimination by either t-test or analysis of variance.

differences between cases and controls may increase on future followup of the patient population, as anemia (particularly megaloblastic) tends to increase with the length of time after operation.^{20,22}

Finally, it is intriguing to postulate that the partial gastrectomy patients might have a significant reduction in their risk of myocardial infarction given their lower weight, cholesterol, triglycerides, and blood pressure. Cigarette smoking was the only important coronary disease associated variable which was more prevalent in the gastrectomy group. Hirohata noted a deficit in deaths

TABLE 6. *Selected Attributes of Gastrectomy Subjects by Proportion of Stomach Resected (Age-Adjusted Means)*

	Less than 2/3 resected (141)	2/3 or more resected (93)
Weight 1940-42 (lb)	130.5	130.4
Weight 1965-68 (lb)	129.2	128.4
Weight change (lb)	-1.3	-2.0
No. cigarettes/day	16.2†	11.8
Hematocrit (%)	44.0	44.3
Serum cholesterol (mg%)	208.3	209.5
Casual triglyceride (mg%)	186.5	208.9
Systolic blood pressure (mmHg)	133.0	133.9
Diastolic blood pressure (mmHg)	78.2	77.0
24-Hour Recall Diet Data		
Calories	2337*	2157
Fat (gm)	86.7*	77.3
Protein (gm)	93.3	92.0
Carbohydrate (gm)	265.8	250.1
No. meals and snacks	5.1	5.1

The asterisks and dagger indicate significant differences by t-test. * $p < .10$ † $p < .05$. Figures in parentheses indicate number of men tabulated.

due to arteriosclerotic heart disease in medically and surgically treated gastric ulcer patients.¹² Accordingly, the possible "protective" effect of gastrectomy is being studied as part of a prospective surveillance program now in progress.

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