Numerical Variation of Parietal Cells after Vagotomy in Cases of Duodenal Ulcer

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AMANO, K. *Numerical Variation of Parietal Cells after Vagotomy in Cases of Duodenal Ulcer.* Tohoku J. exp. Med., 1981, 135 (2), 165-178 — The present study was conducted histologically to elucidate the influence of vagotomy on the gastric mucosa. Bioptical tissues were obtained from 10 control cases and from 26 cases of duodenal ulcer using an endoscope. Of the 26 cases of duodenal ulcer, 20 were subjected to truncal vagotomy with pyloroplasty and 6 to truncal vagotomy with hemigastrectomy. In the cases of duodenal ulcer, tissues were obtained at the preoperative stage, and at 1, 3, 6 and 12 months on the time-course basis after the operation. The parietal cells were counted in a unit area (0.0176 mm²) between the middle and lower 1/3 part of the fundic gland in H.-E. stained paraffin sections under microscopy. The length of the fundic gland was also measured. The results are summarized as follows: (1) There were a greater number of parietal cells and the length of the fundic gland was longer in the preoperative cases than in the controls. (2) Postoperative observations revealed that the number of parietal cells and the length of the fundic gland significantly decreased up to 3 months after the operation by both surgical techniques. Thereafter, the number of parietal cells and the length of the fundic gland significantly increased in the cases subjected to vagotomy with pyloroplasty. (3) The difference between the two surgical techniques was made clear when the mean values for the absolute number of parietal cells were compared at 3 months after the operation, the absolute number of parietal cells being smaller in hemigastrectomy than in pyloroplasty. ——— parietal cells; vagotomy; duodenal ulcer.

Subtotal gastrectomy advocated by Finsterer (1918) used to be the main surgical procedure for duodenal ulcer. However, with an increase of long-term follow-up cases, postoperative sequelae such as malabsorption, weight loss, dumping syndrome and anemia have come to pose various problems.

On the other hand, Dragstedt and Owens (1942) reported that duodenal ulcer is caused by hypersecretion of gastric juice through mediation of the vagus, and they advocated vagotomy. Thereafter, more interests have been shown in this surgical technique. At present, vagotomy appears to have become the main current of surgical technique for duodenal ulcer because the reservoir function of the stomach is preserved relatively well and also because digestion and absorption are kept more physiologically intact following vagotomy than after conventional

partial gastrectomy. There are, however, some reports which suggest that vagotomy is inferior to subtotal gastrectomy when considering postoperative complaints (Shimazu et al. 1973) and that the incidence of postoperative ulcer recurrence is high with vagotomy (Stempien et al. 1971; Kronborg and Madsen 1975). This has triggered the improvements in the surgical technique of vagotomy (Holle 1974) and a number of pathophysiological studies including acid out-put (Olbe 1974), gastric motility (Maric and Code 1975; Reverdin et al. 1980) and gastric blood flow (Delaney 1967; Bell and Shelley 1968).

There have been a few reports of electron or light microscopical observation on the parietal cells after vagotomy on a time-course basis (Sander 1965; Holle et al. 1971; Sano 1976; Yamagishi et al. 1976). However, their observations were mostly of the short duration after vagotomy and histological changes have not been fully investigated, especially in relation to the mechanism of acid reduction which is the main clinical purpose of vagotomy.

Subjects of the present study are the cases of duodenal ulcer, which underwent truncal vagotomy with either pyloroplasty or hemigastrectomy. The gastric mucosa was biopsied before the operation and on a time-course basis till 12 months after the operation. As to the density of the parietal cells and the length of the fundic gland, comparison was first made between the cases of duodenal ulcer and the controls. Further studies were made on the postoperative time-course changes in the density of the parietal cells and the length of the fundic gland in reference also to the operative method.

MATERIALS AND METHODS

Materials. Subjects of the present study consisted of 26 patients who were operated on for duodenal ulcer. Their ages ranged from 20 to 71 years and averaged 45 years. There were 24 males and 2 females. Fifteen out of the 26 were emergency cases, and the remaining 11 cases underwent elective operation. Of the emergency cases, 14 had a perforated duodenal ulcer, one of which showed massive hemorrhage from an ulcer penetrating into the wall of the gallbladder. As for the surgical technique, truncal vagotomy with Heineke-Mikulicz's type of pyloroplasty was performed in 20 cases. Truncal vagotomy with hemigastrectomy was indicated for 5 cases of high preoperative acid out-put and also for one case which had an ulcer penetrating into the gallbladder.

Eight out of the 26 cases were excluded from the postoperative follow-up observation for the following reasons. After the operation, 2 cases showed an early positive Hollander test according to the criteria of Ross and Kay (1964). One case was excluded because of hypergastrinemia after the operation. Five cases could not be followed-up. However, specimens obtained before the operation were investigated.

On the other hand, 10 cases which showed no endoscopical abnormality in the gastric mucosa were used as the controls. The ages of the controls ranged from 23 to 60 years, averaging 43 years. There were 8 males and 2 females.

Biopsy. In each elective case, 4 specimens were biopsied using a gastrofiberscope (GTF type B₂, Olympus, with the light source of GLE, Olympus) before the operation. In each emergency case, 4 specimens were also biopsied with a mucosal forceps at the time of pyloroplasty or hemigastrectomy prior to vagotomy. Postoperative biopsy was performed at 1, 3, 6, and 12 months after the operation.

The center of the anterior wall of the gastric body was selected as the steady site for biopsy both before and after the operations including hemigastrectomy. This is the place

where a biopsy forceps can easily be applied to the gastric mucosa and there are more numbers of parietal cells than in other areas as reported in the literature (Berger 1934; Hoshigo 1953).

Treatment of specimen. Each specimen was placed on a piece of filter paper with the tunica muscularis mucosae facing the paper and in this way it was possible to clarify the direction of the specimen. Specimens were fixed in 2.8% glutaraldehyde for 4 hr and embedded in paraffin. The sections were made in order that the whole longitudinal view of the gastric mucosa could be obtained. The $4\mu\text{m}$ -thick sections were stained with hematoxylin and eosin.

Microscopic examination. Parietal cells were counted after the Berger's method (1934) modified by Hoshigo (1953). A mask corresponding to 0.11 mm in length, 0.16 mm in width and 0.0176 mm^2 in area in tissue sections was inserted into the eye-piece of the microscope for counting the parietal cells. Figs. 1-A and -B illustrate the site and the unit area for counting the parietal cells. The number of parietal cells per unit area was counted in the vicinity of the boundary between the lower 1/3 and the middle 1/3 of the fundic gland where the parietal cells were relatively many and evenly distributed (Berger 1934; Hoshigo 1953). The parietal cells on the upper and left side line of the mask were counted, and those on the right and lower side line were not counted. The count was made in five units at the magnification of 400 times. The number of parietal cells found per unit was designated as the absolute number and the mean number was used for statistical comparison.

The length of the fundic gland was measured in an area showing the fundic gland in its full length the same as with counting parietal cells. The length from the base of the gastric crypt to the blind end of the gland was designated as the length of the fundic gland. The measurement was done using a digital micrometer (OSM-D2, Olympus) under the magnification of 100 times. The measurement was made in five places per case at each time of biopsy. The mean value thus obtained was calculated down to the second decimal

Fig. 1. A: The figure shows the site and the unit area (quadrangle, 0.0176 mm^2) in the fundic gland. The unit is set at the boundary between the lower 1/3 and the middle 1/3 of the fundic gland. A 36-year-old male with duodenal ulcer before operation. t, top of the gland; b, bottom of the gland. H.-E. stain, $\times 70$. B: In a unit area, 17 parietal cells (arrows) are found. $\times 350$.

place and expressed in mm. Further, the corrected number of parietal cells was sought so as to estimate the number of parietal cells in the full length of fundic gland. The corrected number of parietal cells was calculated by multiplying the mean absolute number of parietal cells by the mean length of the fundic gland.

Statistical analysis. The values obtained by the measurement, which was repeated five times in each case, were used for the statistical comparison. The statistical test was carried out at a 5% level of significance. Distribution of the data was confirmed to be normal. After performing the variance test (*F*-test), the *t*-test was applied at each destined time to compare the mean values.

RESULTS

Comparison of the absolute number of parietal cells, the length of the fundic gland and the corrected number of parietal cells between the preoperative cases and the controls

First, the preoperative cases were compared with the controls with regard to the absolute number of parietal cells, the length of the fundic gland and the corrected number of parietal cells. The mean values of controls and duodenal ulcer cases are shown in Figs. 2A, -B and -C, and the results of the statistical data are shown in Table 1.

Absolute number of parietal cells. Comparison was made between the controls and the preoperative cases as to the mean absolute number of parietal cells. The mean values were 16.2 ± 5.2 (mean $\pm$ s.d.) for the controls and 21.4 ± 4.4 for the duodenal ulcer cases, the latter being definitely larger than the former ($i=44.69$).

Length of fundic gland. The mean length of the fundic gland was found to be longer in cases of duodenal ulcer than in the controls ($i=38.79$), the mean value being 0.40 ± 0.08 mm for the controls and 0.49 ± 0.08 mm for the duodenal ulcer cases.

Corrected number of parietal cells. The corrected number of parietal cells was found to be larger in the cases of duodenal ulcer ($i=15.53$), with the mean value of 6.6 ± 2.7 for the controls and 10.6 ± 2.6 for the cases of duodenal ulcer.

Fig. 2. Comparison between controls and cases of duodenal ulcer before operation. A: Mean absolute number of parietal cells per 0.0176 mm^2 . B: Mean length of fundic gland. C: Mean corrected number of parietal cells.

TABLE 1. *Statistical comparison of absolute number of parietal cells, length of fundic gland and corrected number of parietal cells between controls and cases of duodenal ulcer before operation*

		n	$x_{\min}-x_{\max}$	$\bar{x}$	S.D.	$\hat{F}$	$\hat{t}$
Absolute number	Controls	50	8 — 28	16.2	5.2	1.44	44.69*
	Duod. ulcer preop.	130	6 — 31	21.4	4.4		
Length of gland (mm)	Controls	50	0.28—0.60	0.40	0.08	1.36	38.79*
	Duod. ulcer preop.	130	0.32—0.72	0.49	0.08		
Corrected number	Controls	10	4.4 —12.1	6.6	2.7	1.13	15.53*
	Duod. ulcer preop.	26	4.8 —16.2	10.6	2.6		

n , population; $\bar{x}$, mean; S.D., standard deviation; $\hat{F}$, computed F -value; $\hat{t}$, computed t -value.

* Significant difference stands.

Time-course changes in the absolute number of parietal cells, the length of the fundic gland and the corrected number of parietal cells in postoperative cases

Truncal vagotomy with pyloroplasty was performed in 20 cases. Of these, 3 cases were excluded from the study, because 2 cases continued being early positive on the Hollander test and one had hypergastrinemia. Accordingly, the data of 17 preoperative cases were used for statistical analysis. Four cases of truncal vagotomy with pyloroplasty were missed to follow up and their preoperative data only were used. There were 13 cases followed up for 1 month, 6 cases for 3, and 4 cases for 6 months. Two cases could be followed up for 12 months. Six cases were subjected to truncal vagotomy with hemigastrectomy. One case was not followed up, and therefore only its preoperative data were used. Their clinical course was followed up for 1 month in 5 cases, 3 months in 3 and 6 months in 1. Since only 1 case was followed up for 6 months, no attempt was made to compare at 6 months in this case.

Absolute number of parietal cells. The postoperative changes in the absolute number of parietal cells are shown in Figs. 3A and -B. Table 2 is the statistical data at each destined time.

First, the mean values of the absolute number of parietal cells at various destined times were compared in the cases subjected to truncal vagotomy with pyloroplasty. The mean values were 21.7 ± 4.5 before the operation, and 16.1 ± 4.1 at 1 month, 12.6 ± 3.1 at 3 months, 13.0 ± 2.9 at 6 months and 13.9 ± 4.6 at 12 months after the operation.

The mean absolute number was found to have decreased at 1 month as well as 3 months after the operation. The difference was significant with a statistical value of $\hat{t}=66.98$ between the preoperative cases and cases at 1 month after the

Fig. 3. Changes in mean absolute number of parietal cells. A: Truncal vagotomy with pyloroplasty. B: Truncal vagotomy with hemigastrectomy.

TABLE 2. *Statistical comparison of absolute number of parietal cells in cases of duodenal ulcer*

Time after operation (months)	<i>n</i>	$x_{\min}-x_{\max}$	$\bar{x}$	S.D.	$\hat{F}$	$\hat{t}$
T.V. with pyloroplasty						
Preop.	85	6—31	21.7	4.5	1.20	66.98*
1	65	8—25	16.1	4.1	1.68	16.81*
3	30	6—20	12.6	3.1	1.11	0.17
6	20	7—17	13.0	2.9	2.62*	5.00*
12	10	8—21	13.9	4.6		
T.V. with hemigastrectomy						
Preop.	30	14—29	20.3	3.9	1.41	30.69*
1	25	10—21	14.8	3.2	3.82*	4.36*
3	15	9—14	11.5	1.6		
6	5	7—12	9.2	2.0		

n, population; $\bar{x}$, mean; S.D., standard deviation; $\hat{F}$, computed *F*-value; $\hat{t}$, computed *t*-value.

* Significant difference stands.

operation, and with a statistical value of $\hat{t}=16.81$ at 1 and 3 months after the operation. An increase was observed 6 months after the operation, but the difference was not significant. A significant increase was observed in the absolute number of parietal cells 12 months after the operation. However, when compared with the preoperative mean value, it was evident that the number of parietal cells was significantly lower at 12 months with a statistical value of $\hat{t}=27.48$.

The absolute number of parietal cells in the cases subjected to truncal vagotomy with pyloroplasty was shown to decrease up to 3 months after the operation and thereafter increased. However, the increased absolute number of parietal cells

at 12 months after the operation was still smaller than before the operation. The decreasing rate of the absolute number of parietal cells reached a maximum of 41.9% at 3 months after the operation in cases subjected to truncal vagotomy with pyloroplasty.

The same study was also made for the cases which underwent truncal vagotomy with hemigastrectomy. The mean value at each destined time stood at 20.3 ± 3.9 before the operation, and 14.8 ± 3.2 at 1 month, 11.5 ± 1.6 at 3 months and 9.2 ± 2.0 at 6 months after the operation. As compared with the absolute number of parietal cells before the operation, the absolute number of parietal cells significantly decreased up to 3 months after truncal vagotomy with hemigastrectomy. It was found decreased also at 6 months, though the observation was made only in 1 case. The decreasing rate in the absolute number of parietal cells reached a maximum of 43.3% at 3 months after the operation.

The mean absolute numbers of parietal cells after the two surgical techniques were also compared at each destined time. No significant difference was observed as to the mean absolute number of parietal cells before and at 1 month after the operation. However, regarding the value at 3 months after the operation, a significant difference was noted between the two, the absolute number of parietal cells being smaller in the cases of truncal vagotomy with hemigastrectomy ($t=4.33$).

Length of fundic gland. The time-course changes in the length of the fundic gland are shown in Figs. 4A and -B. Table 3 summarizes the statistical data at each destined time. In the cases of truncal vagotomy with pyloroplasty, the mean length of fundic gland at each destined time stood at 0.50 ± 0.10 mm before the operation, and 0.41 ± 0.07 mm at 1 month, 0.35 ± 0.08 mm at 3 months, 0.41 ± 0.06 mm at 6 months and 0.53 ± 0.01 at 12 months after the operation. Thus, it was shown that the length of the fundic gland became shorter up to 3 months

Fig. 4. Changes in mean length of fundic gland. A: Truncal vagotomy with pyloroplasty. B: Truncal vagotomy with hemigastrectomy.

TABLE 3. *Statistical comparison of length of fundic gland in cases of duodenal ulcer*

Time after operation (months)	<i>n</i>	$x_{\min}-x_{\max}$ (mm)	$\bar{x}$	S.D.	$\hat{F}$	$\hat{t}$
T.V. with pyloroplasty						
Preop.	85	0.32—0.69	0.50	0.10	1.68*	6.73*
1	65	0.27—0.62	0.41	0.07	1.96*	4.43*
3	30	0.24—0.42	0.35	0.08	1.14	19.22*
6	20	0.31—0.50	0.41	0.06	2.17	28.87*
12	10	0.45—0.58	0.53	0.01		
T.V. with hemigastrectomy						
Preop.	30	0.34—0.72	0.49	0.20	1.36	11.00*
1	25	0.30—0.56	0.42	0.12	2.34*	4.40
3	15	0.28—0.45	0.37	0.03	—	—
6	5	0.34—0.55	0.46	0.02		

n , population; $\bar{x}$, mean; S.D., standard deviation; $\hat{F}$, computed F -value; $\hat{t}$, computed t -value.

* Significant difference stands.

after the operation. Beyond 3 months after the operation there was a significant and steady increase in the length of the fundic gland between 3 and 6 months ($\hat{t}=19.22$), also between 6 and 12 months after the operation ($\hat{t}=28.87$). Comparison of the mean values before and that at 12 months after the operation revealed a slight difference ($\hat{t}=4.66$).

It was revealed that the fundic gland in the cases of truncal vagotomy with pyloroplasty became shorter up to 3 months after the operation, and then tended to become slightly longer than the preoperative value.

The same study was also made for the cases subjected to truncal vagotomy with hemigastrectomy. The mean length was 0.49 ± 0.20 mm before the operation, 0.42 ± 0.12 mm at 1 month, 0.37 ± 0.03 mm at 3 months and 0.46 ± 0.02 mm at 6 months after the operation. The mean value was shown to decrease up to 1 month after the operation, as well as between 1 and 3 months after the operation with the difference being significant at $\hat{t}=11.00$ and $\hat{t}=4.40$, respectively. This shows that the length of the fundic gland is shortened up to 3 months after the truncal vagotomy with hemigastrectomy when compared with the preoperative condition.

The mean lengths of the fundic gland at destined times were compared in reference to the two surgical techniques before, and at 1 as well as at 3 months after the operation. No significant difference was observed between the two surgical techniques in the mean length of the fundic gland at 1 and 3 months after the operation.

Corrected number of parietal cells. The changes with lapse of time in the corrected number of parietal cells are shown in Figs. 5A and -B. Table 4 summarizes the statistical data at destined times. The mean values in the cases subjected to truncal vagotomy with pyloroplasty were 10.8 ± 2.7 before the operation,

Fig. 5. Changes in mean corrected number of parietal cells. A: Truncal vagotomy with pyloroplasty. B: Truncal vagotomy and hemigastrectomy.

TABLE 4. *Statistical comparison of corrected number of parietal cells in cases of duodenal ulcer*

Time after operation (months)	<i>n</i>	$x_{\min}-x_{\max}$	$\bar{x}$	S.D.	$\hat{F}$	$\hat{t}$
T.V. with pyloroplasty						
Preop.	17	4.8—16.2	10.8	2.7		
1	13	4.4—8.4	6.5	1.4	3.65*	5.96*
3	6	2.7—6.2	4.5	1.1	2.08	1.35
6	4	3.1—6.9	5.5	1.5	3.61	0.88
12	2	5.0—9.7	7.4	2.4		
T.V. with hemigastrectomy						
Preop.	6	7.4—15.2	10.0	2.5		
1	5	4.6—7.4	6.1	1.0	5.94	8.94*
3	3	4.2—4.3	4.3	0.1	374.54*	3.59*
6	1	4.3	4.3	—	—	—

n, number of cases; $\bar{x}$, mean; S.D., standard deviation; $\hat{F}$, computed *F*-value; $\hat{t}$, computed *t*-value.

* Significant difference stands.

and 6.5 ± 1.4 at 1 month, 4.5 ± 1.1 at 3 months, 5.5 ± 1.5 at 6 months and 7.4 ± 2.4 at 12 months after the operation. The mean value at 1 month after the operation showed a decrease when compared with the preoperative value with a significant difference ($\hat{t}=5.96$). Also, the mean value was significantly less from 1 month to 3 months after the operation ($\hat{t}=9.03$). The corrected number of parietal cells decreased significantly up to 3 months after the operation. The mean values tended to increase slightly at 6 and 12 months after the operation. There was a difference between the mean values at 3 and 12 months after the operation with a significant increase ($\hat{t}=155.52$). It became clear that the corrected number of

parietal cells in the cases subjected to truncal vagotomy with pyloroplasty decreased up to 3 months, and then gradually increased. Also the number of parietal cells increased at 12 months after the operation as compared with the value 3 months after the operation.

The mean corrected number of parietal cells at each destined time in the cases subjected to truncal vagotomy with hemigastrectomy was also studied. The mean values were 10.0 ± 2.5 before the operation, and 6.1 ± 1.0 at 1 month and 4.3 ± 0.1 at 3 months after the operation. A significant decrease was found between the mean values before the operation and at 1 month after ($t=8.94$) as well as between the mean values at 1 and 3 months after the operation ($t=3.59$). The corrected number of parietal cells also showed a decrease up to 3 months after the operation even in the cases subjected to truncal vagotomy with hemigastrectomy. When the mean corrected number of parietal cells at each destined time was compared in reference to the two surgical techniques, there was no significant difference between the two before and at 1 month after the operation. At 3 months after the operation, however, the mean corrected number of parietal cells was found to be smaller in the cases subjected to truncal vagotomy with hemigastrectomy ($t=6.66$).

DISCUSSION

With specimens biopsied under direct vision after vagotomy, Holle et al. (1971), Kato (1976) and Watanabe et al. (1978) made histological observations of the gastric mucosa on a time-course basis. Berger (1934) and Hoshigo (1953) examined the density and distribution of the parietal cells in normal cases and cases of duodenal ulcer. Hoshigo (1953) reported that the number of parietal cells decreased slightly in cases of duodenal ulcer when compared with normal cases, but the length of the fundic gland was longer, and suggested that the total number of parietal cells in the entire gastric mucosa did not change in duodenal ulcer. In the present study, however, both the absolute number of parietal cells and the length of the fundic gland were increased in the cases of duodenal ulcer when compared with the controls. The corrected number of parietal cells gave similar results. After vagotomy, the fundic gland revealed clearly that the absolute number of parietal cells decreased at 1 and 3 months after the operation.

Sander (1965) performed transperitoneal vagotomy on rats and reported that the absolute number of parietal cells did not decrease until 12 weeks after operation. Posey et al. (1968) also reported a similar result from an experiment in dogs. However, many reports are available which support the decrease in number of the parietal cells after vagotomy (Holle et al. 1971; Kato 1976; Watanabe et al. 1978). Holle et al. (1971) performed biopsies in 20 cases of duodenal ulcer from 11 to 45 days after vagotomy and reported that the density of parietal cells revealed an average decrease of 36.15%. Kato (1976) made a follow-up observation for 1 year after operation, and found that the rate of decrease in number of the parietal cells was 40% after selective vagotomy with antrectomy, 27.2% after

antrectomy only and 18.5% after selective vagotomy with pyloroplasty. In the present study, the maximum rate of decrease in number of parietal cells was 41.9% after truncal vagotomy with pyloroplasty and 43.3% after truncal vagotomy with hemigastrectomy.

The length of the fundic gland also decreased up to 3 months after truncal vagotomy with either pyloroplasty or hemigastrectomy. Crean et al. (1969a) followed up five weeks after vagotomy in rats and reported that the thickness of the mucosa decreased. Sano (1976) pointed out atrophy of the fundic gland after vagotomy in rats. They also maintained that the changes of the chief cells would be related to the decrease in the length of the fundic gland.

Judging from the proportion of parietal cells in the fundic gland, the decrease in the length of the fundic gland cannot be explained merely by the decrease in number of the parietal cells. The quantitative change of the chief cells which occupy a large proportion of the fundic gland should be taken into consideration, although the chief cells were not counted in the present study. The decrease of the parietal cells would be due to the inhibited production of parietal cells after vagotomy, as was suggested by Ley et al. (1973) who examined deoxyribonucleic acid synthesis and the mitotic index through the intraperitoneal injection of H^3 -thymidine. With electron microscopic observation, Kato (1976) and Watanabe et al. (1978) found a deformation of vesicles and falling off of free ribosomes in the parietal cells after vagotomy and also pointed out the diminishing function of the parietal cells after vagotomy.

Martin et al. (1970) reported a decrease in number of both parietal cells and chief cells after antrectomy alone in rats. Therefore, it should also be considered that hemigastrectomy added to vagotomy induces reflux of bile into the stomach, a decrease of gastrin and changes in the hemodynamics of the stomach which might influence gastric acidity and the number of parietal cells.

In the cases of pyloroplasty, the absolute number of parietal cells and the length of the fundic gland started to increase beyond 3 months after the operation. The antrum is known to have plenty of gastrin-secreting cells (Tobe et al. 1974; Stave and Brandtzaeg 1978). An experimental antrocolic transposition resulted in hyperplasia of the parietal cells as well as the chief cells in the fundic gland of the remnant stomach (Lehy et al. 1973). As can be seen from reports on the numerical increasing of parietal cells and the thickening of the fundic mucosa following a long-term administration of gastrin (Crean et al. 1969b), gastrin clearly has an action to accelerate the growth of the gastric mucosa. With both surgical techniques either with or without hemigastrectomy in the present study, there was no significant difference in the mean values for the absolute number of parietal cells before the operation and at 1 month after the operation. At 3 months after the operation, the mean value for the absolute number of parietal cells decreased as compared with that before the operation, but the number was clearly smaller in the cases subjected to hemigastrectomy than in the cases subjected to pyloroplasty. Comparison of the results between the two surgical techniques suggests that the

presence or absence of the antrum is related to the difference in the absolute number of parietal cells.

Only one case of hemigastrectomy added to vagotomy could be followed up until 6 months after the operation, which allowed no definite comparison with other cases subjected to pyloroplasty. The absolute number of parietal cells, however, tended to increase from 3 to 6 months after the operation in the cases subjected to pyloroplasty, while it showed a tendency to decrease during the same period in the case subjected to hemigastrectomy.

The relationship between the acid-reducing effect (the main clinical purpose of vagotomy) and the number of parietal cells is further commented. Card and Marks (1960) reported that the maximum acid output was proportional to the number of parietal cells. On the other hand, Halaris (1971) suggested that the long-term acid-reducing effect was caused by cholinergic deficit following vagotomy, but the atrophic changes of the parietal cells and the fundic gland were caused by transient ischemia. In the present study, a decrease in the number of parietal cells was observed up to 3 months after the operation, and thus the decrease in the number of parietal cells appeared to be closely concerned with the acid-reducing effect. After that, however, the number of parietal cells increased, so that the decrease in the number of parietal cells and the length of fundic gland up to 3 months after the operation are interpreted as a transient change. Dragstedt et al. (1951) and Johnston et al. (1973) made long-term follow-up studies of gastric acid output after vagotomy and found the steady recovery of acid output. It is of interest that their findings seem to coincide with the result of the present study which revealed an increase of the number of the parietal cells and the length of the fundic gland after their transient decrease for the initial 3 months.

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