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STUDIES ON THE QUANTITATIVE EVALUATION OF THE FUNCTION OF STOMACH AND DUODENUM

2. STATISTICAL STUDIES ON CORRELATIONS BETWEEN MEASUREMENT ITEMS OF X-RAY FIGURES

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Abstract

As previously reported, the following 8 items were measured on gastric x-ray images: 1) width at the section of gastric angle (Ba) and gastric body (Bc), and Ba/Bc ratio ; 2) length of antral border at the lesser curvature (L) and the greater curvature (G), and G/L ratio ; 3) middle zone thickness (MZ) ; 4) sawtoothed wave depth (Zhnlg) ; 5) antral peristalsis (AP) ; 6) antral spasm (AS) ; 7) length of duodenal loop (L of D) and 8) number of duodenal longitudinal folds (Lf).

Using correlation coefficient and scatter diagram or correlation table in analyzing correlations between four sets of 2 items covering 5 groups, namely Ba/Bc and G/L, MZ and G/L, G/L and AP, and MZ and Zhnlg, and obtained the following results: 1) correlation between Ba/Bc disappeared in the open stage of gastric ulcer ; 2) correlation between MZ and G/L disappeared in the open stage of either gastric ulcer or duodenal ulcer ; 3) correlation between G/L and AP was negative in any one of the groups and 4) correlation between MZ and Zhnlg showed a higher level in the open stage of duodenal ulcer. The above findings presumably indicate characteristic correlations depending on the group.

INTRODUCTION

Roentgenologic examination of the stomach is used habitually as the first choice in the diagnosis of peptic ulcer since it requires but a simple technique and clinically enables us to obtain ample information regarding the course of the development of such ulcer with less discomfort to patients. However, since it has been rather common among physicians to rely on subjective factors

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in their routine film reading, it would certainly help to improve their diagnoses if they were able to read x-ray images more objectively. Therefore, I have currently undertaken a basic study on the quantitative evaluation of diagnoses in an attempt to clarify pathophysiological aspects of the roentgenologic examination.

Previously, I studied[1] 8 items of filling pictures of the stomach in the upright position consisting of 5 groups and compared correlations between respective items for performing statistical analysis. In this current study, having obtained correlation coefficients between 2 of these items covering 5 groups, investigation was performed on signifying correlations of relatively higher level between four sets of 2 items by referring them to correlation coefficient on scatter diagram or correlation table.

MATERIALS AND METHODS

Included in the current study were normal cases (group N : 102 males and 12 females with an average age of 48.5), those in the open stage of gastric ulcer (group GU : 41 males and 6 females with an average age of 49.3), those in the scar stage of gastric ulcer (group GS : 33 males and 6 females with an average age of 51. 9), those in the opening stage of duodenal ulcer (group DU : 31 males and 8 females with an average age of 41. 9) and those in the scar stage of duodenal ulcer (group DS : 22 males and 6 females with an average age of 43. 6) : gastric x-ray films used are detailed in the previous study,[1] and both the roentgenography and quantitative method used are exactly the same as those previously employed.

With the methods currently employed, I obtained all the correlation coefficients among 8 items of 5 groups which were determined in the previous study, and prepared either scatter diagram or correlation table for investigating the correlation of relatively higher levels between four sets of 2 items, namely Ba/Bc and G/L, MZ and G/L, G/L and AP, and MZ and Zhnlg.

RESULTS

The following are the results, obtaining from analytical study on the correlation between four sets of 2 items.

1) Ba/Bc vs. G/L : Correlation coefficients were 0.26 and 0.38 in groups N and GS, respectively, whereas the same in group GU was -0.03 (Fig. 1). On the other hand, as shown in Fig. 2, 0.31 and 0.33, equally positive correlations, were noted in groups DU and DS. These 2 items of Ba/Bc and G/L suggest that correlation between the two still exists in the open stage of duodenal ulcer and that the same no longer exists in the open stage of gastric ulcer.

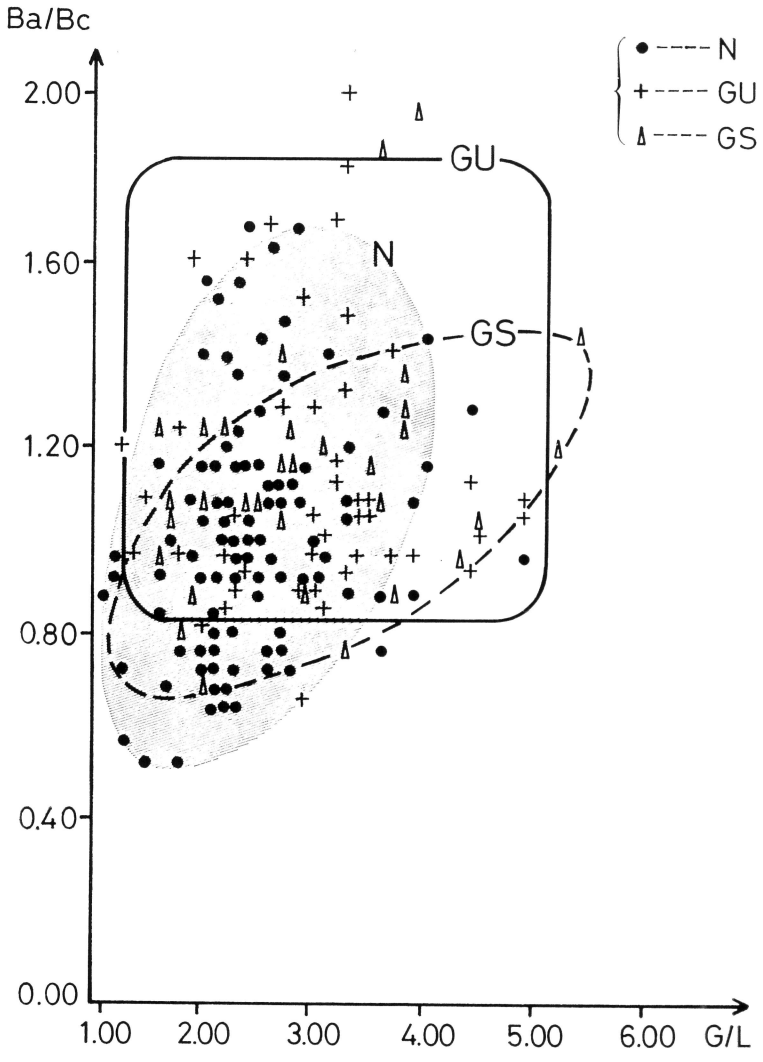

Fig. 1. Scatter Diagram between Ba/Bc and G/L
(N group, GU group, GS group)

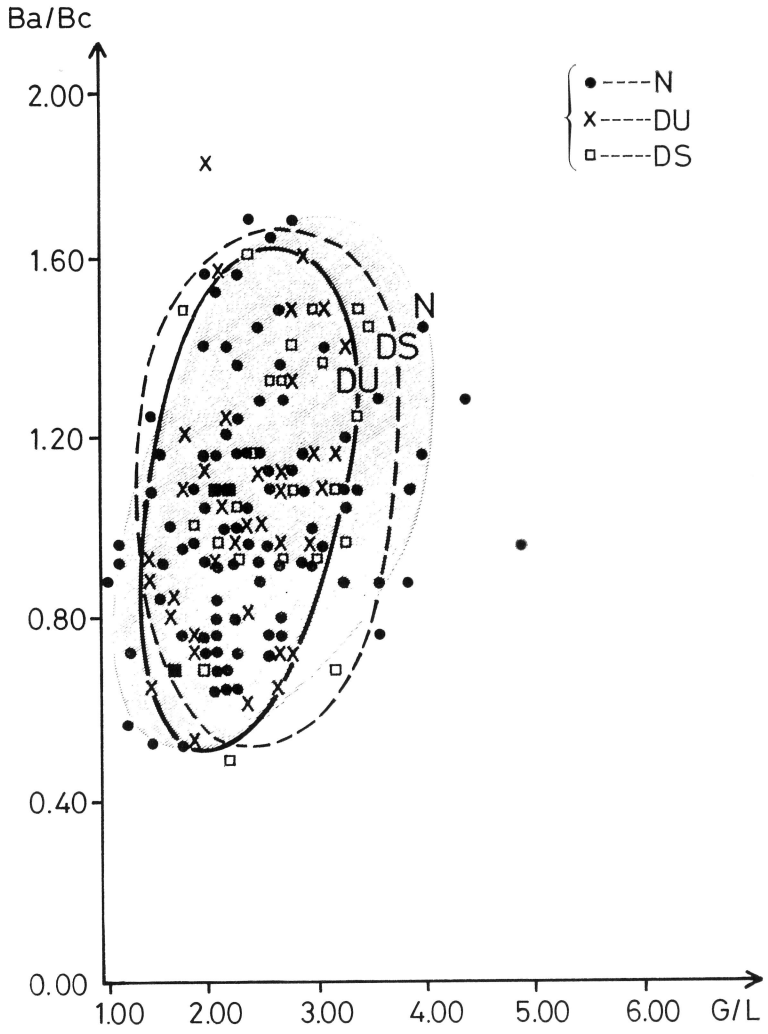

Fig. 2 Scatter Diagram between Ba/Bc and G/L
(N group, DU group, DS group)

2) MZ vs. G/L : Correlation in group N was 0.30, but no correlation was recognized in the open stage of gastric ulcer, with 0.00 and 0.27 in groups GU and GS, respectively (Fig. 3). Correlations recognized in groups DU and DS were -0.02 and 0.37, respectively, suggesting that as in the case of gastric ulcer, correlation is lost in the open stage of duodenal ulcer (Fig. 4).

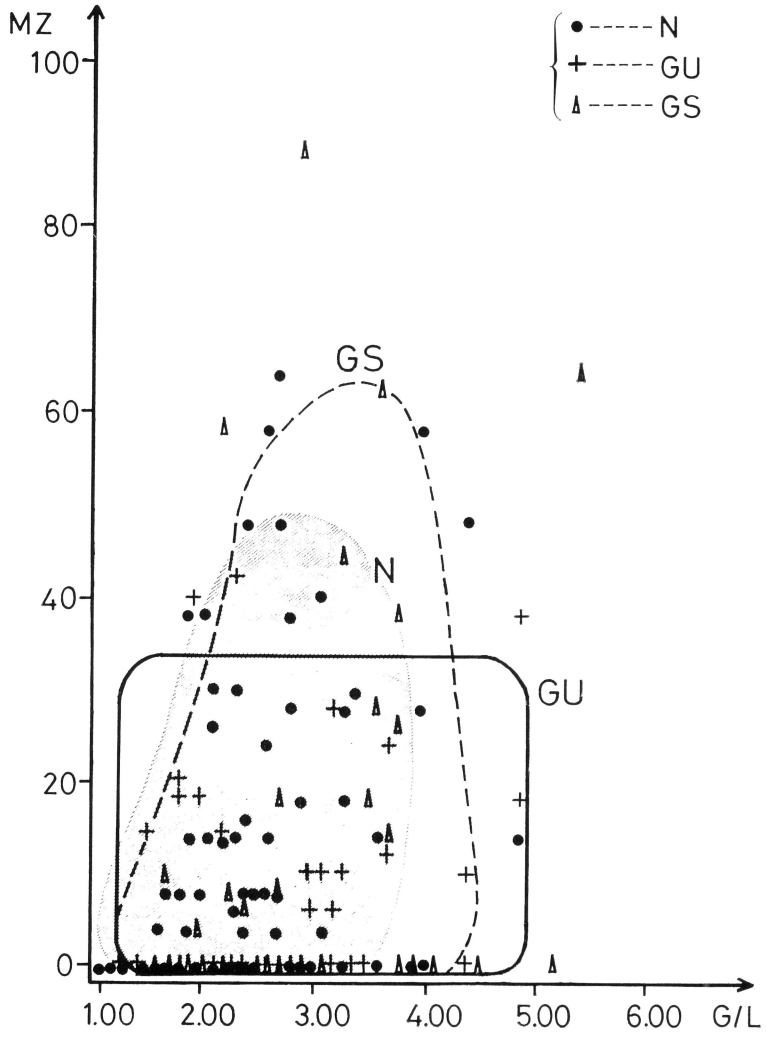

Fig. 3. Scatter Diagram between MZ and G/L
(N group, GU group, GS group)

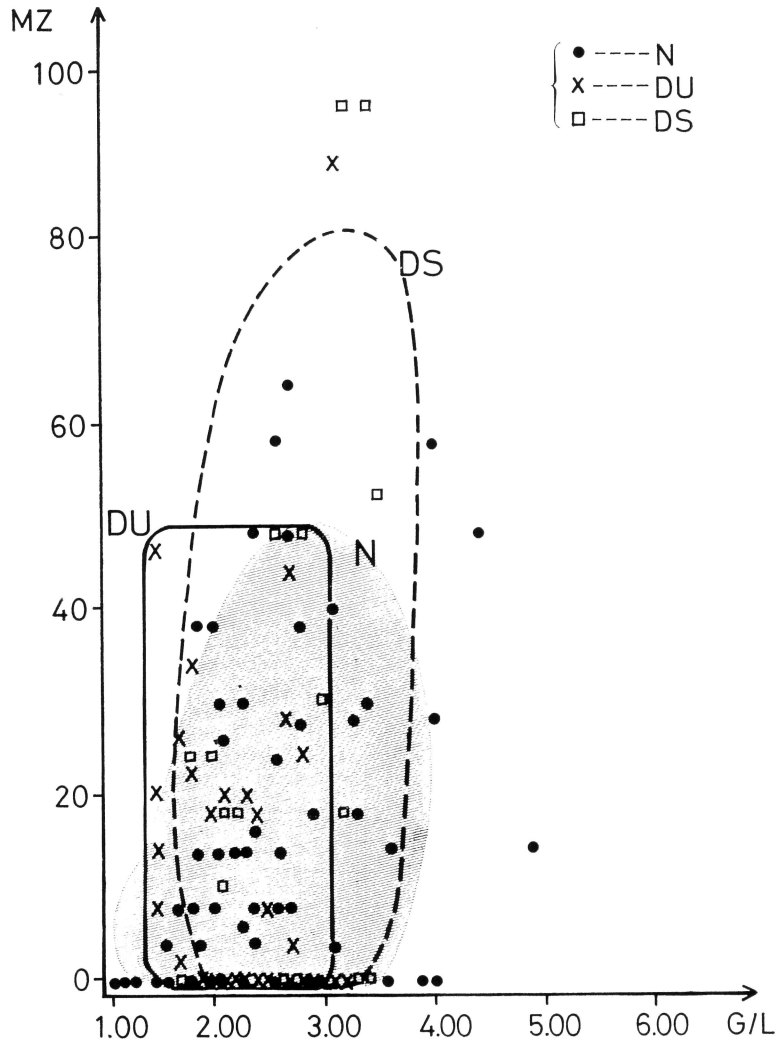

Fig. 4. Scatter Diagram between MZ and G/L
(N group, DU group, DS group)

3) G/L vs. AP : Correlation coefficients between G/L and AP were -0.26, -0.23, -0.34, -0.40 and -0.26 in groups N, GU, GS, DU, and DS, respectively, which were equally negative correlations. Tables 1-3 show AP classified by the levels of 0, 1 and 2, and G/L by the levels above 3,097, 2,420 to 3,097, 1,743 to 2,420 and lower than 1,743, together with the number of gastric x-ray film subject to investigation and related percentages in the brackets.

4) MZ vs. Zhnlg : Correlation of the highest level was recognized in group DU, followed by group N and group GS in that order (Table 4-6).

TABLE 1. Correlation Table between G/L and AP (N group)

N-group

G/L \ AP	0	1	2	
3.097-	9 (8.8)	5 (4.9)	0 (0)	14
2.420- 3.097	15 (14.7)	12 (11.8)	1 (1.0)	28
1.743- 2.420	16 (15.7)	28 (27.5)	4 (3.9)	48
-1.743	4 (3.9)	7 (6.9)	1 (1.0)	12
	44	52	6	102

	MEAN ± S.D.
A P	0.63 ± 0.594
G/L	2.42 ± 0.677

Coefficient of correlation
r = - 0.26

DISCUSSION

1) Ba/Bc vs. G/L : These two items are considered to indicate the degree of tonus of gastric wall components of the gastric body and the pyloric antrum, particularly the tonus of proper muscle layer. It is quite interesting that correlation in the GU group alone proved to be extremely low as a result of this investigation of the correlation coefficient pertaining to each group.

This indicates that as compared with that existing in the gastric body wall, some kind of deviation had conceivably occurred in the tonus on the part of lesser and greater curvatures of the gastric wall in the pyloric antrum due to an open ulcer existing in the stomach, for the correlation between Ba/Bc and

TABLE 2. Correlation Table between G/L and AP
(GU group, GS group)

GU-group

G/L \ AP	0	1	2	
3.097-	6 (13.0)	9 (19.6)	1 (2.2)	16
2.420-3.097	5 (10.9)	7 (15.22)	3 (6.5)	15
1.743-2.420	2 (4.4)	4 (8.7)	4 (8.7)	10
-1.743	0 (0)	5 (10.9)	0 (0)	5
	13	25	8	46

	MEAN ± S.D.
AP	0.89 ± 0.667
G/L	2.93 ± 0.852

Coefficient of correlation
r = -0.23

GS-group

0	1	2	
6 (15.0)	8 (20.0)	0 (0)	14
1 (2.5)	8 (20.0)	1 (2.5)	10
1 (2.5)	9 (22.5)	1 (2.5)	11
1 (2.5)	2 (5.0)	2 (5.0)	5
9	27	4	40

	MEAN ± S.D.
AP	0.88 ± 0.563
G/L	2.89 ± 0.969

Coefficient of correlation
r = -0.34

G/L is considered to have deviated in group GU alone.

Primarily, Ba/Bc may be considered as an indication of mainly the tonus between the gastric body and angle, and G/L as an indication of the tonus between lesser and greater curvatures in the pyloric antrum. On the other hand, it is known that[2] contraction force of the gastric wall gradually becomes stronger than that in the gastric body, in the site ranging from the gastric angle to the gastric pylorus, when the thickness of proper muscle layer and peristaltic movement force of the proper muscle layer of gastric wall are taken into consideration.

From the above findings, it is quite possible that an increased stretch on the part of the greater curvature toward the gravitational direction due to an intragastric barium weight greatly raises the G/L level when the tonus in the pyloric antrum is extremely weak.

TABLE 3. Correlation Table between G/L and AP
(DU group, DS group)

DU-group

G/L \ AP	0	1	2	
3.097-	0 (0)	1 (2.5)	0 (0)	1
2.420- 3.097	2 (5.0)	8 (20.0)	5 (12.5)	15
1.743- 2.420	0 (0)	8 (20.0)	9 (22.5)	17
-1.743	0 (0)	2 (5.0)	5 (12.5)	7
	2	19	19	40

	MEAN ± S.D.
AP	1.40 ± 0.587
G/L	2.31 ± 0.527

Coefficient of correlation
r = -0.40

DS-group

0	1	2	
1 (3.5)	3 (10.3)	0 (0)	4
0 (0)	8 (27.6)	2 (6.9)	10
0 (0)	6 (20.7)	7 (24.1)	13
1 (3.5)	1 (3.5)	0 (0)	2
2	18	9	29

	MEAN ± S.D.
AP	1.24 ±0.577
G/L	2.53 ± 0.523

Coefficient of correlation
r = -0.25

Although it should not be concluded that because groups GU and GS do not belong to the same case that correlation does exist in group GS but is lost in group GU, this may indicate a relation getting closer to group N following ulcerous cicatrization. No significant difference was recognized between group N and groups DU and DS in the results obtained from F-test, t-test and Welch's test carried out on Ba/Bc and G/L in the previous study. This suggests that duodenal ulcer has less effect on these 2 items.

2) MZ vs. G/L : MZ is closely related to gastric excretion, but since none of the subjects involved in the present study had an excretion disorder, MZ level was naturally higher in patients with a higher level of secretion because the amount of gastric juice produced in hunger, particularly the basic volume of nocturnal secretion, was considerably affected. However, not only the amount of secretion but also peristaltic movement of an empty stomach[3] and biliary reflux[4] would certainly affect MZ levels as well.

TABLE 4. Correlation Table between MZ and Zhnlg (N group)

N-group

MZ \ Zhnlg	1	2	3	
41.28-	1 (0.9)	3 (2.7)	3 (2.7)	7
25.39-41.28	6 (5.3)	4 (3.5)	1 (0.9)	11
9.50-25.39	9 (8.0)	4 (3.5)	0 (0)	13
0-9.50	62 (54.9)	11 (9.7)	9 (8.0)	82
	78	22	13	113

	MEAN ± S.D.
Zhnlg	1.42 ± 0.692
MZ	9.50 ± 15.890

Coefficient of correlation
r = 0.25

Regarding the basic amount of nocturnal secretion considerably affecting MZ level, Wada et al.[5] determined dynamic secretion by continuous aspiration and found that the largest amount was secreted in patients with duodenal ulcer, followed by patients with gastric ulcer and normal subjects in that order. It was recognized at the same time that patients with duodenal ulcer who showed higher secretion curves than normal subjects had normal levels restored after treatment.

It is therefore not appropriate to treat the MZ level as an indication of the basic amount of nocturnal secretion of gastric juice since this level, as shown by gastric x-ray film, is composed of rather complicated factors as was proved by the results obtained by Wada et al. Nevertheless, the results of this investigation of correlation between MZ and G/L, an item indicating a tonus, revealed that correlation in groups GS and DS was an approximation

TABLE 5. Correlation Table between MZ and Zhnlg
(GU group, GS group)

GU - group

MZ \ Zhnlg	1	2	3	
41.28-	0 (0)	0 (0)	0 (0)	0
25.39- 41.28	3 (6.3)	1 (2.1)	0 (0)	4
9.50- 25.39	5 (10.4)	3 (6.3)	1 (2.1)	9
0- 9.50	24 (50.0)	7 (14.6)	4 (8.3)	35
	32	11	5	48

	MEAN ± S.D.
Zhnlg	1.44 ± 0.681
MZ	7.94 ± 12.142

Coefficient of correlation
r = -0.01

GS - group

1	2	3	
2 (4.9)	3 (7.3)	0 (0)	5
2 (4.9)	1 (2.4)	0 (0)	3
2 (4.9)	1 (2.4)	0 (0)	3
20 (48.8)	10 (24.4)	0 (0)	30
26	15	0	41

	MEAN ± S.D.
Zhnlg	1.37 ± 0.488
MZ	12.68 ± 22.447

Coefficient of correlation
r = 0.20

to that of group N ; this is worth noting, but further details have yet to be clarified.

3) G/L vs. AP : These items are equally used for determination in relation to the pyloric antrum. Although AP correlation with Ba/Bc, whose counterpart is considered as an indication of proper muscular tonus of the gastric body, shows a lower level, the same as with G/L, a probable indication of proper muscular tonus of the pyloric antrum is more likely. This suggests to us of a case in which peristaltic movement in the pyloric antrum could hardly occur in a patient with a higher G/L level and another in which G/L showed, on the contrary, a lower level because of the occurrence of peristaltic movement.

If, as Asahi[6] has described, amplitude, duration and area of contraction waves of the gastric angle on the part of the lesser curvature equally tend to be larger even in the pyloric antrum, the former is acceptable since the G/L level becomes higher instead of showing a decline.

TABLE 6. Correlation Table between MZ and Zhnlg
(DU group, DS group)

DU-group

MZ \ Zhnlg	1	2	3	
41.28-	2 (4.7)	2 (4.7)	0 (0)	4
25.39- 41.28	2 (4.7)	1 (2.3)	0 (0)	3
9.50- 25.39	7 (16.3)	3 (7.0)	1 (2.3)	11
0 - 9.50	22 (51.2)	3 (7.0)	0 (0)	25
	33	9	1	43

	MEAN ± S.D.
Zhnlg	1.26 ± 0.492
MZ	14.28 ± 19.328

Coefficient of correlation
r = 0.31

DS-group

1	2	3	
4 (13.8)	1 (3.5)	0 (0)	5
1 (3.5)	0 (0)	0 (0)	1
3 (10.3)	3 (10.3)	0 (0)	6
13 (44.8)	4 (13.8)	0 (0)	17
21	8	0	29

	MEAN ± S.D.
Zhnlg	1.28 ± 0.455
MZ	17.10 ± 26.987

Coefficient of correlation
r = 0.07

However, the speed of transmission of peristaltic movement waves in the pyloric antrum gradually increases[7], and as shown in electromyograms, the greater curvature plays the major role[8,9] in propagating a slow spike rather than the lesser curvature; the propagation speed on the part of the greater curvature is higher as well[10]. Furthermore, specificity of the muscle structure of gastric wall participating in peristaltic movement waves on the part of greater and lesser curvatures may be a factor that cannot be neglected.

As was previously pointed out by Groedel[11], movement in the pyloric antrum largely deviates between greater and lesser curvatures. On the other hand, Forssel[12] attributed the movement to a structural factor (highly differentiated musculature of the transverse stomach), while Pernkopf[13,14], mentioned in his report that it does not originate from a structural difference but is an entirely functional movement.

This is a problem that has to be solved in our future studies, but we

have to take into consideration the specificity of the muscle structure of the pyloric canal which Wernstedt[16] and Schwalbe[17] had previously referred to, as well as the specific muscle structure of the gastric angle section that can be noted when the proper muscle layer is observed from an interior aspect of the gastric wall, which Torgersen[15] had pointed out from the viewpoint of comparative anatomy other than the fact that right and left loop canals exist on the part of the greater curvature, accompanied by the pyloric canal and muscle torus on the part of the lesser curvature.[15]

4) MZ vs. Zhnlg : Gastric rugae have often been interpreted or explained rather sensibly in both endoscopic and roentgenologic diagnoses although its composition and function have not been clarified as yet. In fact, no clear-cut interpretation regarding the relation between gastric rugae and saw-toothed wave shown in the filling figure in the upright position has been given to data.

Takemoto et al.[18] endoscopically observed dynamic changes of gastric rugae and reported its relation with the atrophic pattern of gastric membrane. They also reported that as compared with that of an open type, gastric rugae of a closed type tends to disappear or become flat with a fixed amount of air blast, but giant rugae does not disappear easily.

Although no special attention has been paid to Zhnlg in roentgenologic diagnoses of the stomach except when particular diseases such as Menetrier's disease, malignant lymphoma and cancer of stomach have to be examined, I think it necessary to treat it in future as an indication of a concrete phenomenon.

SUMMARY

1. Correlation between four sets of 2 items of Ba/Bc and G/L, MZ and G/L, G/L and A/P, and MZ and Zhnlg was studied in GU, GS, DU and DS groups of peptic ulcer and a normal group covering a total of 5 groups, expressing them with correlation coefficient, scatter diagram or correlation table.
2. When four sets of 2 items of roentgenologic images of gastric ulcer and duodenal ulcer originating in different sites of development of peptic ulcer were analyzed, the following characteristics were recognized : 1) correlation between Ba/Bc disappeared in the open stage of gastric ulcer ; 2) correlation between MZ and G/L disappeared in the open stage of either gastric ulcer or duodenal ulcer ; 3) correlation between G/L and AP was negative in any one of the groups and 4) correlation between MZ and Zhnlg proved to be higher in the open stage of duodenal ulcer.
3. Observation of these items was considered necessary in roentgenologic diagnoses of peptic ulcers since they could be indications of the existence of either gastric ulcer or the course of its improvement.

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