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# Roentgenologic Studies on Diseases of the Stomach

## Report 5. Changes in contour and peristalsis

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### 胃疾患に関する X 線学的研究

#### 第5報 胃の輪郭及び蠕動運動について

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われわれは最近、胃 X 線所見について胃病変の性状との関係を詳細に比較検討するとともに、その輪郭および蠕動運動について分析を行なつたところ興味ある知見を得たのでここにその概要を報告した。

一般に、胃の輪郭および蠕動は X 線撮影手技、患者の体位、病変の部位、時期、深さ、広がり等により大きく影響される。胃充盈像についてみると立位では造影剤の重力により胃壁は伸展されるので、胃の辺縁より離れた小病変 (En face lesion) は診断しにくく、辺縁にある病変 (Profile lesion) においても小さく浅い病変はしばしば診断が困難であつた。これに反して背臥位ないし腹臥位二重造影法では前処置、体位変換等の併用により、辺縁病変のみならず、前、後壁にある病変も良好に描出し得た。また、大きい病変、深い病変、隆起した病変、線維化した病変、辺縁に近い病変等では高率に異常輪郭を示し、蠕動は減弱ないし欠如した。

辺縁にある病変では、従来報告されているように陰影欠損、ニッシェ、壁不整、壁硬化、対側の陥入、その他の変形等が認められ、蠕動はしばしば減弱ないし消失した。

辺縁に近い病変、または辺縁より離れていても大きな病変、深い病変等ではしばしば細胞浸潤による膨隆、線維化したものではその収縮により陥凹等を示した。その他、局所的、非対称的な蠕動小波、波状の辺縁、辺縁の交叉現象、対側の陥入等が認められた。

したがって辺縁病変はもちろんのこと病変が辺縁より離れ直接造影されていない症例においても、以上の所見を示すものではその異常波の分析により、病変の位置、広がり等をある程度推定することが出来た。

しかしながら、これらの輪郭および蠕動の異常のみによつては病変の良、悪性の質的診断はしばしば困難であつた。

#### Preface

On X-ray examinations of the stomach, we have recently undertaken various mucosal studies, such as mucosal folds with a small amount of barium, double contrast, and compression technique (Saito et al., 1966, 1969). And a precise analysis of the contour and peristalsis on barium filled stomach and the mucosal studies disclosed facts of great interest. Untill the present time such a precise study has been scarcely made. Therefore, we want to report in this paper.

### Materials and Methods

In the past 4 years, 9 early gastric cancers (the lesion confined to the mucosa or submucosa of the gastric wall), 5 slightly advanced cancers (the lesion partly reached to the muscular coat), 3 advanced cancers (the lesion reached to the muscular coat or serosa), 3 benign small gastric polyps (below 5 mm. in diameter), 2 benign middle-sized polyps (6 to 15 mm. in diameter), 2 benign large polyps (above 16 mm. in diameter), 16 benign small gastric ulcers (below 5 mm. in diameter), 7 benign middle-sized ulcers (6 to 15 mm. in diameter), and 5 benign large ulcers (above 15 mm. in diameter) were selected at random at the Radiology Department of Gunma University Hospital.

On these 52 cases including 64 lesions, X-ray examinations were made in all cases. Moreover, in all of the 9 early gastric cancers, 5 slightly advanced cancers, 3 advanced cancers, 4 benign gastric polyps, 7 benign, middle-sized gastric ulcers, and 5 benign large ulcers, gastric operations were made, and the diagnosis was histologically confirmed in all. On 16 benign small gastric ulcers, in 4 of them gastric operations were made and diagnosed histologically, and in another 19 cases they were clinically diagnosed according to the gastroscopic study, clinical and laboratory findings, or clinical course.

In this report, measurements of the lesion in size were made from the shadow on the film. Sites of the lesion were divided into the following 3 portions:

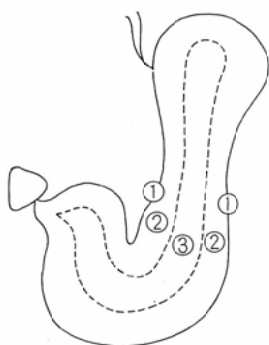


Fig. 1. Sites of the lesion

- ① On lesser or greater curvature: Profile lesion
- ② Near curvatures: Semi-profile lesion
- ③ In central portion: En face lesion

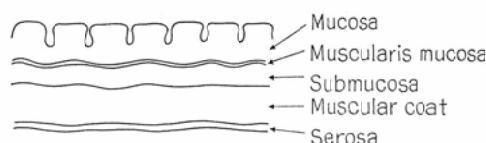


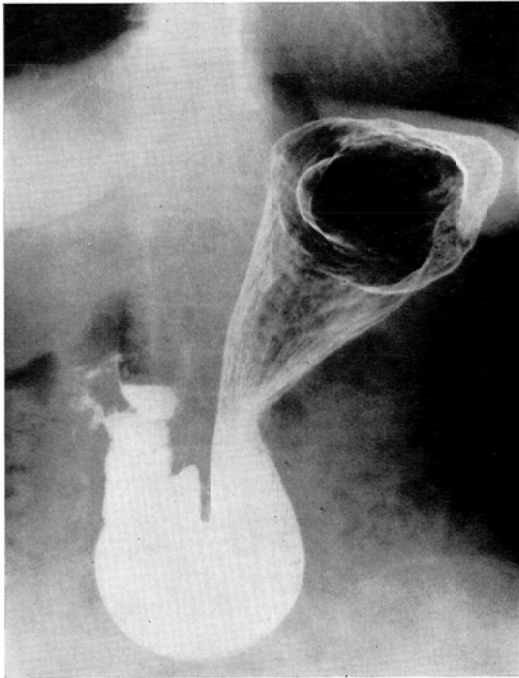
Fig. 2. Depths of the lesion

(1) on the lesser or greater curvature (profile lesion), (2) near the curvatures (semi-profile lesion), (3) central portion of the anterior or posterior wall of the stomach (en face lesion) (Fig. 1). The depths of the lesion were divided into the following 5 layers, according to the anatomical structure of the stomach wall: (1) the mucosa, (2) muscularis mucosa, (3) submucosa, (4) muscular coat, and (5) serosa (Fig. 2). The stages in benign ulcers were divided into 3 parts, according to the clinical course and radiographical findings: (1) acute, (2) middle, and (3) chronic or cicatrical stages.

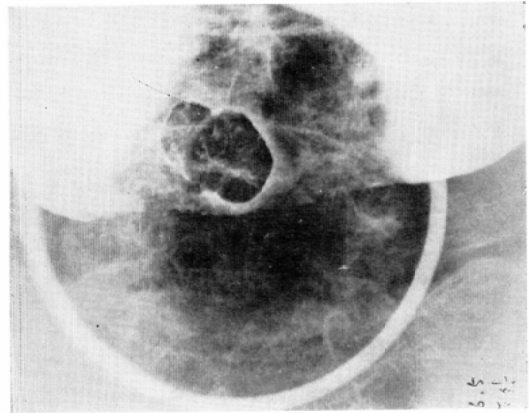
### Results

- I. Gastric cancer (17 cases, including 18 lesions)
  - A. Early gastric cancer (9 cases, 10 lesions)

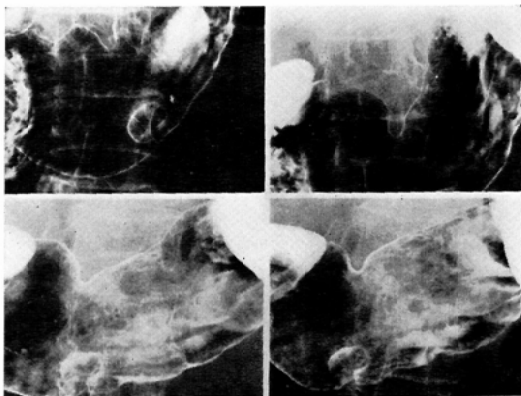
Two lesions of protruding early cancer: The lesions located on the lesser and greater curvatures of the gastric body, respectively (profile lesion). In the former, the contour on the barium filled film showed a small filling defect at the site of the lesion, and the peristalsis was diminished. However, in the latter



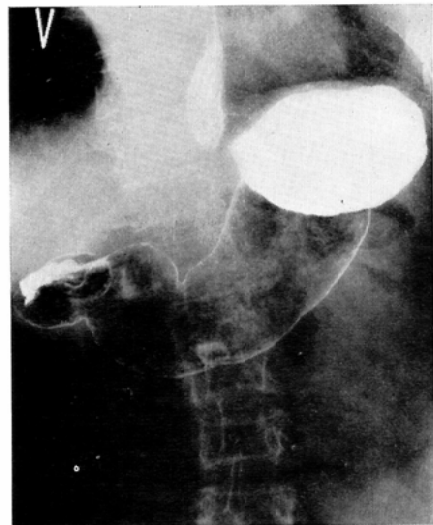
(A)



(B)



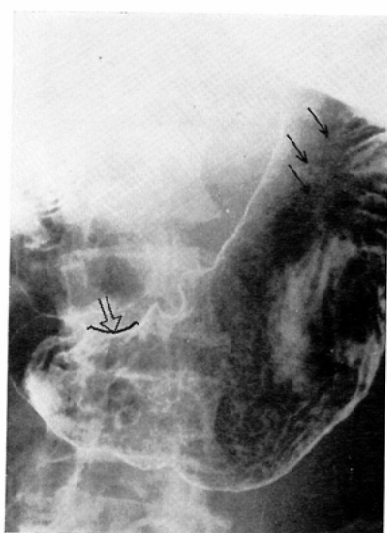
(D)



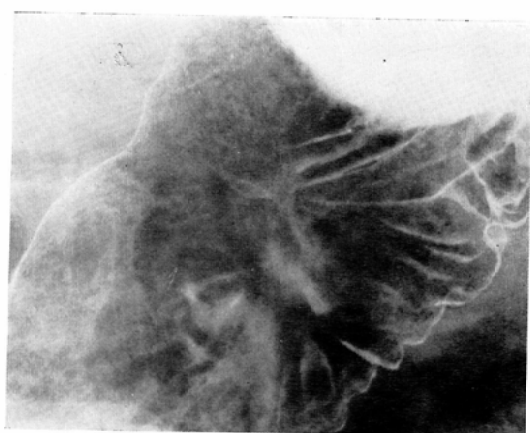
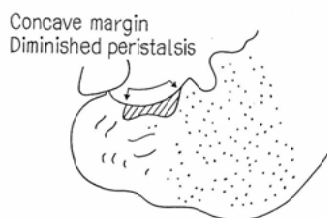
(C)

Fig. 3. Protruding early gastric cancer: A thumbtip-sized pedunculated profile lesion.

- A. Barium-filled film: The contour is almost normal.
- B. Compression technique: A lobulated tumor is clearly demonstrated on the greater curvature.
- C. Double contrast technique: The tumor is also clearly visualized, and the contour shows a concave margin.
- D. Spot double contrast: The contour shows an indentation (arrow).



(A)



(B)

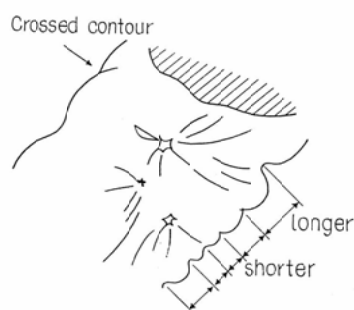
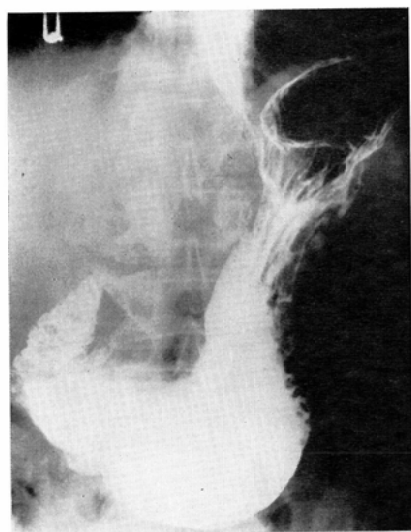


Fig. 4. Protruding early gastric cancer associated with multiple benign ulcers.

- A. Double contrast shows a protruding cancer (ㄣ) and multiple benign ulcers (ㄣ). Peristalsis is markedly diminished at the site of the protruding cancer.
- B. Double contrast shows multiple en face niches, wavy contour, and cross phenomenon of the contour (crossed contour) (arrow). Note sizes of waves.

the contour on the barium filled film was almost normal (Fig. 3A). In both a thumbtip sized, lobulated tumor was clearly demonstrated, respectively, by means of compression or double contrast technique (Fig. 3B, C), and the contour showed a concave margin or indentation at the site of the lesion (Fig. 3C, D).

Two lesions of slight protruding early cancer: Both lesions located on the lesser curvature of the pylorus and antrum with a broad base, respectively. On the barium filled films, the contour was irregular and rigid at the site of the lesion. In one of them the gastric angle was opened (so-called "opened angle"). Fluoroscopically, the peristalsis was distinctly diminished at the site of the protruded and thickened portion (Fig. 4A).



(A)



(B)

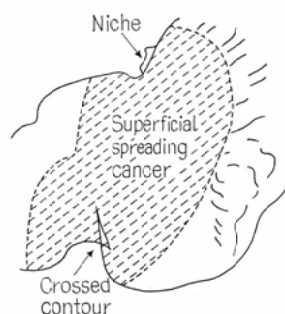
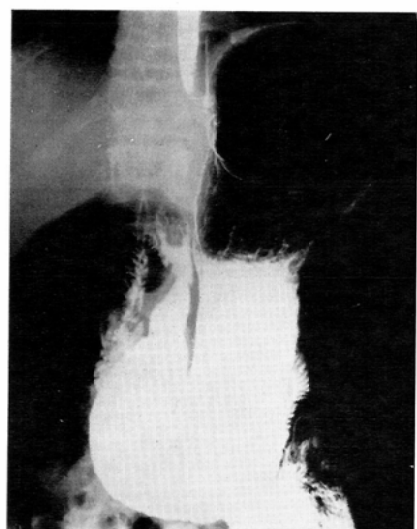


Fig. 5. Superficial spreading early gastric cancer with ulceration

- A. Barium filled film shows irregular contour, rigidity, opened angle (double arrows), and an indentation.
- B. Supine double contrast shows a hen egg-sized lesion with a shallower niche. On the greater curvature of the antrum an indentation and crossed contour are observed.

One lesion of superficial spreading cancer with ulceration: On the barium filled film, the contour was irregular and rigid at the site of the lesion, and showed "opened angle" (Fig. 5A). On the double contrast film the lesion was a hen egg in size and associated with a shallow niche at the gastric angle. On the other hand, an indentation and cross phenomenon of the contour (crossed contour) were observed on the greater curvature of the antrum (Fig. 5B).

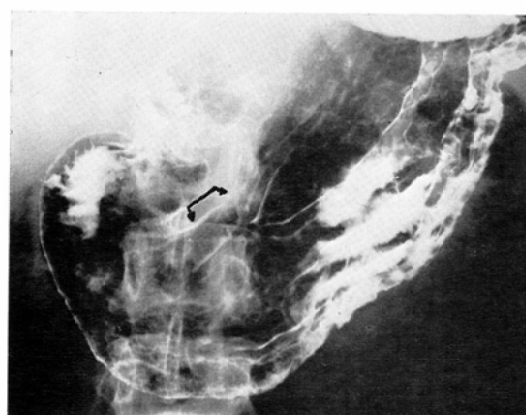
Two lesions of slight concaving early cancer: In both the lesions were an index finger-tip in size, respectively, and the contour on the barium filled film was almost normal (Fig. 6A). On the double contrast the 2 lesions located at the center (en face lesion) and near the lesser curvature (semi-profile lesion)



(A)



(B)



(C)

Fig. 6. Slight concaving early gastric cancer: Semi-profile lesion (anterior wall lesion).

- A. Barium-filled film shows almost normal contour.
- B. Prone double contrast shows a convex margin near the lesion (arrows)
- C. Supine double contrast shows a malignant semi-profile lesion. Near the lesion the contour shows a convex margin (arrows), and peristalsis is diminished in this portion (Double arrows).

of the anterior wall of the stomach, respectively. In the former, the peristalsis was almost normal, but in the latter it was diminished in the surrounding area of the lesion (Fig. 6B, C).

One lesion of concaving early cancer: This was a profile lesion at the angle of the stomach. On the barium filled stomach, the lesion showed rigid contour and opened angle (Fig. 7A). On the double contrast, a thumb-tip-sized irregular niche and break of the mucosal folds were clearly visualized (Fig. 7B).

Two mixed early cancers: In both, the concaving early cancer associated with protruding lesions, respectively. In the one, the barium filled stomach showed opened angle and irregular and rigid contour at the site of the gastric angle. The spot double contrast film showed a hen egg-sized lesion, and the peristalsis was distinctly diminished at the site of the protruded and thickened portion (Fig. 8).

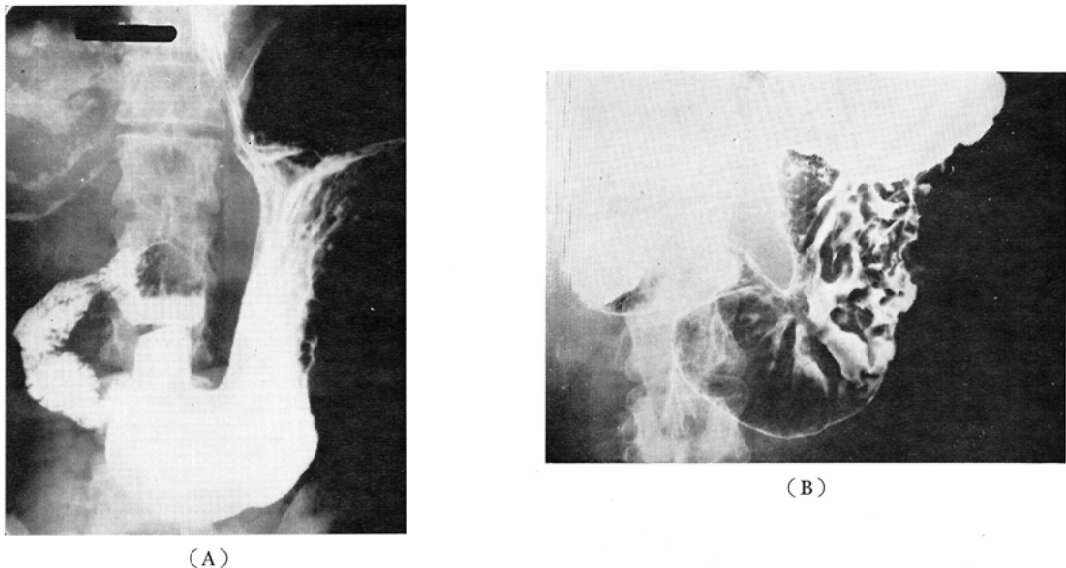


Fig. 7. Concaving early gastric cancer: Profile lesion.

- A. Barium-filled film shows opened angle and rigid contour at the angle.  
 B. Double contrast shows a malignant ulcer.

In the other, the lesion was a walnut in size and located at the center of the posterior wall of the antrum, apart from both curvatures. On the double contrast film, the stomach rotated, and the lesion tended to approach on the greater curvature due to the rotation. Therefore, the changes in the contour and peristalsis became more prominent.

#### B. Slightly advanced gastric cancer (5 cases, 5 lesions)

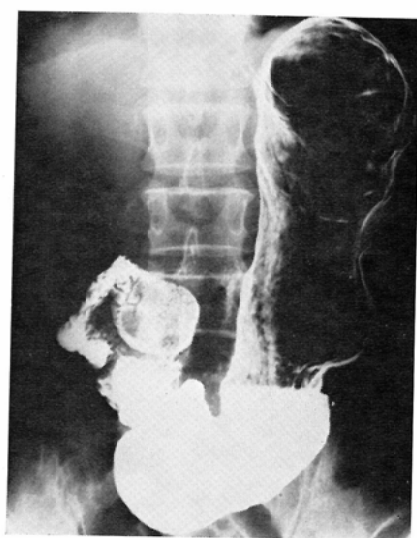
Profile lesions were observed in 3 of the 5, semi-profile lesions in one, and en face lesion in one. In 4 of the profile and semi-profile lesions, the contour showed abnormalities, such as irregularity, rigidity, filling defect, niche, shortening of the curvature, opened angle, and indentation on the opposite side. In all cases the peristalsis was diminished or absent at the site of the lesions. These abnormalities were prominent in profile lesions.

In regard to technique, the abnormalities were more obvious in horizontal positions than in erect positions. And according to large amounts of barium or air, normal portion was remarkably stretched, however, at the site of lesions the stretching was less remarkable (Fig. 9).

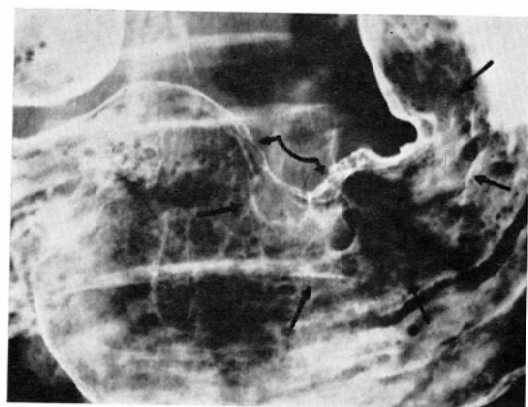
#### C. Advanced gastric cancer (3 cases, 3 lesions)

Out of 3 lesions, profile lesions were found in 2, semi-profile in one. In all cases, the abnormalities, as mentioned above, were observed. In 2 cases, the abnormal contour was more clearly demonstrated by large amounts of barium than small amounts. As a rule, larger and deeper lesions or protruded and thickened profile lesions show more prominent changes, however, these lesions are scarcely stretched by large amounts of barium.

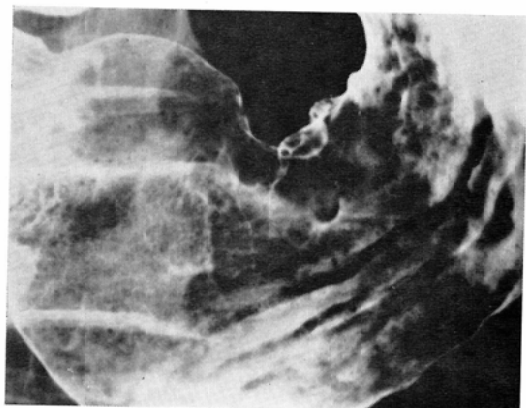




(A)



(B)



(C)

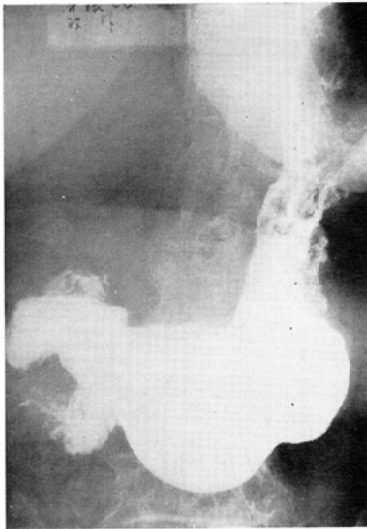


(D)

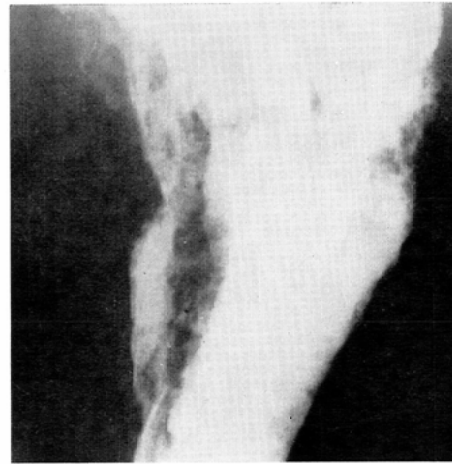


(E)

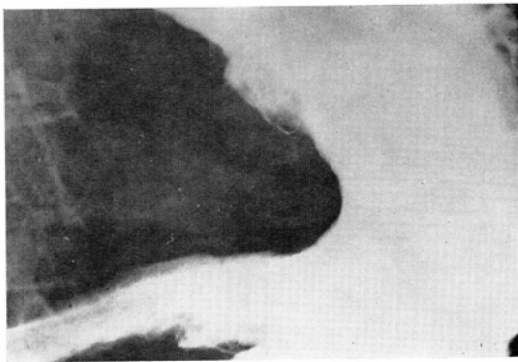
Fig. 8. Protruding cancer and peristalsis:  
Profile lesion  
A. Barium-filled film shows irregular and rigid contour.  
B—E. Double contrast shows markedly diminished peristalsis at the site of the protruded cancer.



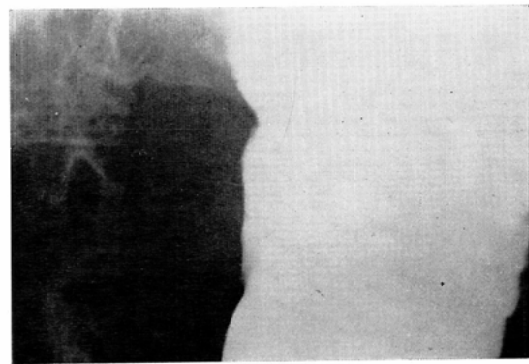
(A)



(B)



(C)



(D)



(E)

- Fig. 9. Slightly advanced gastric cancer
- A. Barium filled film shows a shallower niche on the lesser curvature of the body.
  - B. Compression film shows a malignant niche.
  - C. In supine position with relatively small amounts of barium, the niche projects beyond the luminal contour.
  - D and E. In supine position with large amounts of barium the niche becomes less remarkable, because of the lesion is more akinetic than the normal portion.

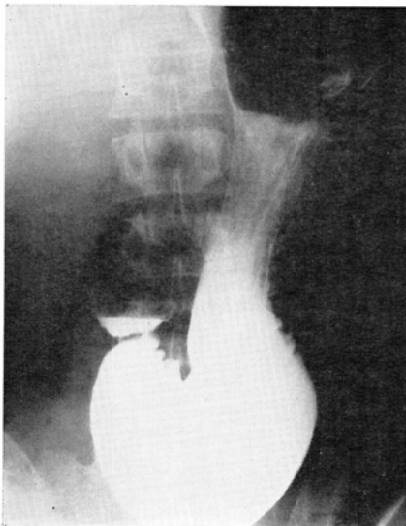
## II. Benign gastric polyps (7 cases, 8 lesions)

Profile lesions were demonstrated in 1 of 8 polyps, and the contour on the barium filled film showed a filling defect. Semi-profile lesions were shown in 2, and en face in 5 polyps. Out of these 8, only large polyp showed an abnormal contour and two large polyps showed abnormal peristaltic waves on the spot double contrast film. As a rule, in large polyps with a broad base, the contour and peristalsis show remarkable changes, while in small polyps with a small stalk, the changes are little.

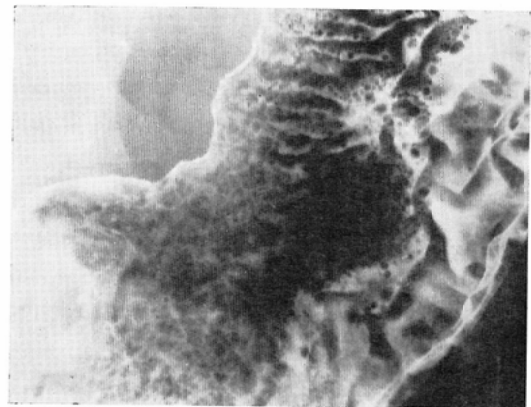
## III. Benign gastric ulcer (28 cases, 38 lesions)

### A. Small gastric ulcer (16 cases, 24 lesions)

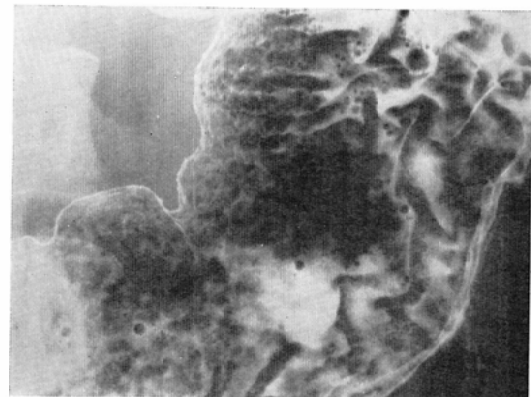
Profile lesions were observed in 8 of the 24, and the niche projected beyond luminal contour in all lesions. But on barium filled films in erect position, the small niche was less remarkable, while on double contrast films in supine or prone position the niche markedly projected beyond the contour. The niche



(A)



(B)



(C)

Fig. 10. Benign multiple gastric ulcers.

- A. Barium filled stomach shows hypersecretion, slightly deformed gastric angle, indentations of the antrum and slight shortening of the lesser curvature.  
 B and C. Supine double contrast shows multiple cicatricial small ulcers, and small localized asymmetrical peristaltic waves are clearly observed on the lesser curvature.

which is located near the gastric angle, often showed an opened angle. In some cases an indentation on the opposite side and shortening of the lesser curvature were visualized in the chronic stage of the disease. In one case of multiple gastric ulcers, the contour on the barium filled film in erect position, showed a little change, but on the supine double contrast film, multiple cicatrical small ulcers and small localized asymmetrical peristaltic waves were clearly found on the lesser curvature (Fig. 10).

Semi-profile lesions were found in 10 of the 24 polyps. On the barium filled film in erect position, the abnormal contour was visualized in 4 of the 10 (40.0%). While, on the spot supine double contrast, the abnormal contour was observed in 6 of the 10 (60.0%), and diminished peristalsis in 3 (30.0%).

En face lesions were demonstrated in 6 of the 24 polyps, and the abnormal contour on the barium filled film was visualized in 1 of the 6 (16.7%). On the spot double contrast, the abnormal contour was observed in 2 (25.0%), and the abnormal peristalsis in 2 (25.0%).

#### B. Middle-sized gastric ulcer (7 cases, 7 lesions)

Profile lesions on the lesser curvature were demonstrated in 4 of the 7 lesions, and on the barium filled film in erect position, the niche projected beyond the luminal contour in all of the 4 lesions. On the supine double contrast film, the abnormal contour was visualized in all cases. In another 3 of the 7 lesions, which were 2 semi-profile and one en face niches, the abnormal contour and peristalsis were observed in all of the 3 lesions (Fig. 11, 12). Abnormal wavy and crossed contours were clearly shown on the supine or prone double contrast film (Fig. 4B, 12).

#### C. Large gastric ulcer (5 cases, 7 lesions)

In all cases, the lesions showed the abnormal contour and peristalsis on both films of double contrast and barium filled films, in spite of the location of the lesion (Fig. 13). In some cases, the abnormalities were more distinctly visualized by large amounts of barium than small amounts.

Usually, in profile lesions in the acute stage of gastric ulcers, the niche markedly projects beyond the luminal contour. While, in the chronic stage, it becomes less remarkable.

Changes in the surrounding area are less remarkable in the acute stage; while in the chronic stage, they become more prominent, especially in large deeper cicatrical ulcers (Fig. 13).

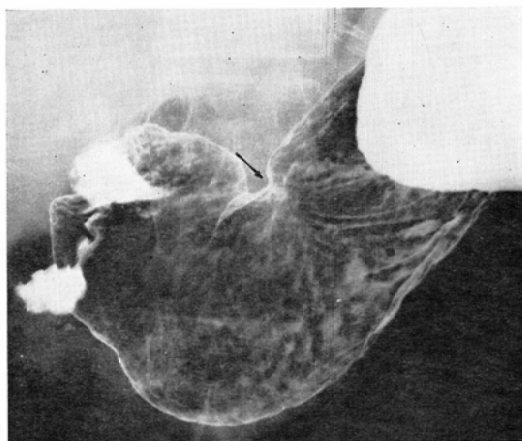


Fig. 11. Middle-sized benign gastric ulcer: Semi-profile lesion. Supine double contrast shows a typical benign ulcer with converged mucosal folds.

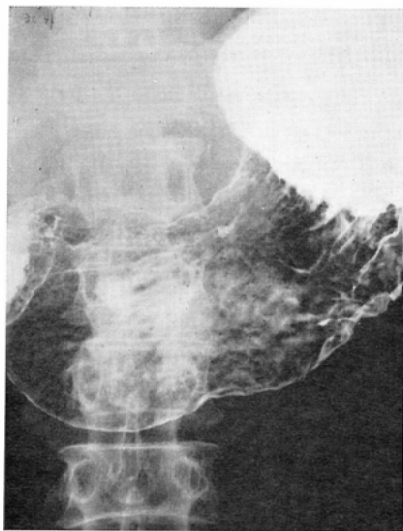


Fig. 12. Middle-sized benign gastric ulcer: Semi-profile lesion. Supine double contrast shows a benign ulcer with converged folds. The lesser curvature near the lesion shows wavy and crossed contours (arrows).

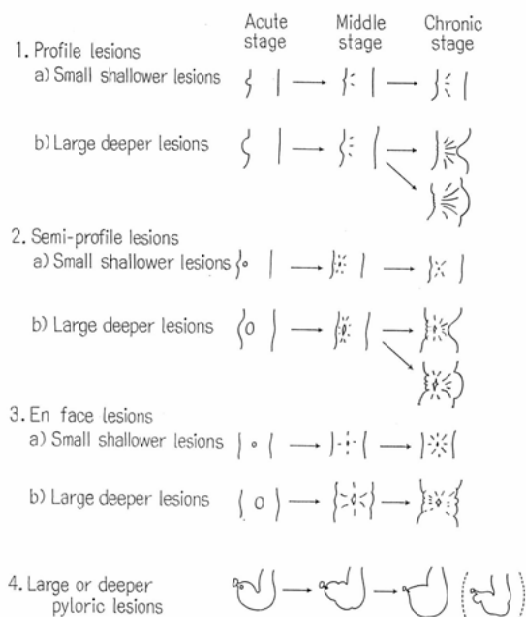


Fig. 13. Relationship between changes in contour and the size, depth, location and stage of lesions.

In cases of semi-profile or en face lesion, the contour often shows a convex outline in the acute stage, and a concave margin in the chronic stage (Fig. 13).



remarkable changes. And the lesion which is located apart from both curvatures (en face lesion) showed the smallest change.

As for the profile lesion in benign gastric ulcers, the niche in the acute stage clearly projected beyond the luminal contour, and the Hampton line, ulcer collar, or ulcer mound (Wolf and Marshak, 1957) was seen by compression technique. The ulcer floor was generally smooth. In the acute stage, the surrounding area was edematous, and the peristalsis was normal or slightly diminished. While in the chronic stage the lesion showed various changes, such as a somewhat irregular niche or contour, converging mucosal folds, shortening of the curvature, opened angle, and indentation on the opposite side.

It is agreed upon that multiple gastric ulcers, a niche associated with a smooth hourglass constriction, a deep smooth on the opposite side, and markedly dilated pylorus stenosis are often indicative of a benign ulcer (Bockus, 1966; Margulis and Burkenne, 1967; Schinz et al., 1967; Shanks and Kerley, 1958; Teschendorf, 1964).

On the other hand, in gastric cancer the lesion often shows an irregular filling defect or crater and irregular or rigid contour. Generally the malignant ulcer does not project beyond the luminal contour. One of the first description of a mass in conjunction with an ulcer crater was that of Carman, known as the Meniscus sign (Carman, 1921; Kirklin, 1934). In studying mucosal folds, a break at the ulcer margin has been reported, and a step-like contour, nodularity in ulcer floors, large shallower niche, and niche on the greater curvature are more indicative of carcinoma than benign ulcer (Bockus, 1966; Ichikawa et al., 1964; Kalokerinos, 1967; Margulis and Burkenne, 1967; Schinz et al., 1967; Shanks and Kerley, 1958; Shirakabe et al., 1966; Teschendorf, 1964).

Gutmann (1939, 1956) described the following characteristics of a small niche commonly due to carcinoma: (a) niche with a flat floor, (b) depressed niche, (c) niche on an even floor, and (d) niche with a crescent-shaped ring-wall. Furthermore, he suspected the following two characteristics of malignancy: (e) a root of the niche, and (f) curtain-shaped folds (Drape) on the greater curvature opposite a niche on the lesser curvature.

Peristalsis in gastric cancer was slightly diminished in small or early lesions, which in large advanced



Fig. 15. Localized cross phenomenon of the contour often occurs near the lesions.

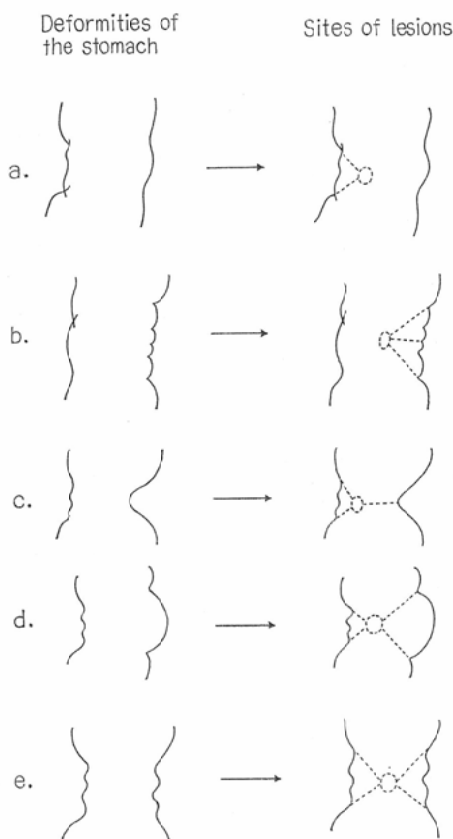


Fig. 16. Relationship between deformities of the stomach and sites of lesions

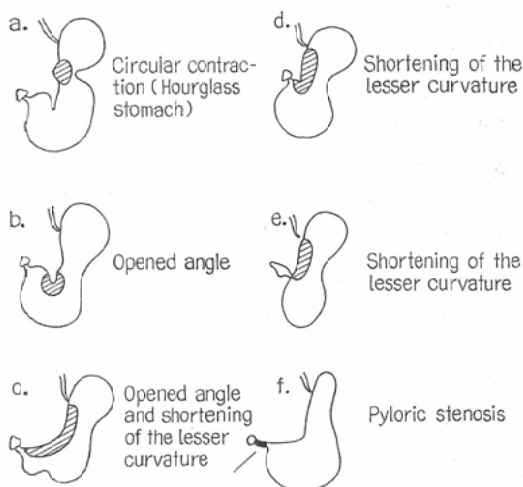


Fig. 17. Other deformities of the stomach and site of lesions

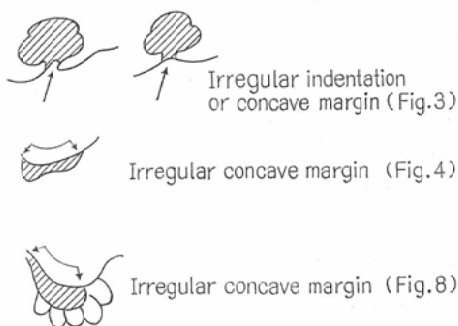


Fig. 18. The contour of protruding early cancer in profile view

cancers it was absent.

On semi-profile or en face lesions of benign gastric ulcers, the contour in the acute stage showed a convex margin due to edema or inflammation in the gastric wall. In the chronic stage it showed a concave margin, local wavy outline, cross phenomenon of the contour (crossed contour), opened angle, and shortening of the curvature. In small central lesions in the acute stage, the contour and peristalsis were often normal.

However, in cases with abnormal contour, the size and site of the lesion may be suspected, according to the changes in the contour as shown in Figs. 15, 16, 17, even if the lesion was not visualized.

In cases of benign gastric polyps on the barium filled film, the profile lesion showed a filling defect or indentation at the site of the lesion, while the en face lesion generally showed normal contour, especially in a small polyp. As a rule, a large polyp or polyp with a broad base often showed abnormal contour and peristalsis. However, in a small polyp or a polyp with a small stalk, there was little change.

In malignancy of gastric polyps, various frequencies ranging from 10 to 35% have been reported



(Brunn and Pearl, 1926; Cromer et al., 1949; Stewart, 1931; Miller et al., 1930).

As a rule, larger (above 20 mm. in diameter), sessile (or broad base), irregular, lobulated, multiple polyps or measurably growing polyps are frequently malignant (Pearl and Brunn, 1943; Rieniets and Broders, 1946; Hay, 1951; Davies and Jackson, 1959; Eklöf et al., 1960; Monaco et al., 1962; Bockus, 1966; Schinz et al., 1967). In our cases, protruding early cancers in profile view often showed an indentation and concave margin (Fig. 18).

As mentioned above in some cases of gastric cancer, the changes in the contour and peristalsis were similar to those of benign chronic ulcers or polyps. Therefore, the differential diagnosis was occasionally difficult, especially in early or small gastric cancer.

For the diagnosis of early or small lesions on the barium filled film, the profile view must be taken. Therefore, if the lesion is suspected anywhere in the stomach, the X-ray film must be made not only in postero-anterior, but also in all projections. For this purpose, cineradiographic studies may be useful. However, in practice, the lesion occurs frequently on the lesser curvature, posterior wall, or near the lesser curvature. So the X-ray films must be taken in the postero-anterior, right (or left) anterior oblique, and lateral projections.

The combined application of these barium filled films and the relief studies, such as mucosal folds, double contrast and compression techniques may be more useful (Saito et al., 1969).

### Summary

We have recently undertaken an analysis of changes in contour and peristalsis on barium filled films by means of mucosal studies. In comparing X-ray and pathological findings, the changes are considerably affected by following factors.

Regarding technique, the changes on the barium filled film in erect position were less remarkable, while on the double contrast in supine or prone position, the changes were more prominent. And early or small lesions often were stretched according to large amounts of barium or air, and became less remarkable.

In regard to stages in benign ulcers, generally in the acute stage, the niche with smooth margin was more obvious.

Concerning size, in small lesions the changes were less remarkable, whereas in large lesions were more obvious.

In regard to depth, the lesion confined to the gastric mucosa showed little change, while the lesion reaching the muscular coat or serosa had changes of more prominent. Therefore, in the former often the lesion was clearly demonstrated by relatively small amounts of barium than large amounts, and in the latter often the lesion was more distinctly visualized by relatively large amounts of barium than small amounts.

As for sites, profile lesions located on the curvature showed the most prominent change, while en face lesions located away from the curvature showed little changes. Protruding early cancers in profile view often showed an indentation and concave margin.

A localized wavy contour, cross phenomenon of the contour (crossed contour), convex or concave outline, and small asymmetrical waves often suggested the existence of semi-profile or en face lesions, and according to these changes, the size, site and depth of the lesion may be suspected in same degree.

If the lesions are examined in the profile view, the changes in the contour are useful to detect early or small lesions. However, the differential diagnosis between malignant and benign lesions is very difficult,

especially in early or small lesions. For practical purposes, therefore, the combined application of the barium filled films (in postero-anterior, right [or left] anterior oblique, and lateral projections) and the relief studies, such as mucosal folds technique, double contrast and compression techniques may be necessary. Cineradiographic studies are also recommended for this purpose.

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