X-ray Diagnosis of Early Gastric Cancer

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Abstract
The authors introduced the present state of diagnosis and treatment of gastric cancer in Japan. Japanese classification of “early gastric cancer” is also introduced. Several X-ray pictures of 7 cases of early gastric cancer with their macroscopical and microscopical findings according to the order of this classification are presented.

The role and superiority of double contrast technique in detecting and making diagnosis of early gastric cancer are discussed.

The possibility of marked shrinkage of benign ulcer existing inside the early gastric cancer lesion is presented, and the importance of following up the course of all the benign ulcer cases for making preoperative X-ray diagnosis is emphasized.

The key point to diagnosis of flat type early gastric cancer (IIb type) is also described.

Preface
In the past few years, the techniques to find out gastric cancer have made marked progress in Japan, so that such minute lesions, which nobody would have expected to be able to find out, can now be diagnosed with accuracy before operation.

In the past, judgment on accuracy of the preoperative diagnosis could only be rendered by the surgeon through laparotomy and subsequent palpation of the stomach. At present, however, even a minute change, which cannot be discerned as a pathological lesion through such palpation or even through a direct look into the inside of the stomach by opening the gastric wall, can be clearly demonstrated on gastro camera film or on X-ray films preoperatively. Further more, by means of a gastroscope with biopsy curette, a reliable histological diagnosis can be settled preoperatively for a slight lesion which cannot be confirmed even by a pathologist without a close scrutiny of the resected specimen is now possible.

In this paper, the authors, after introducing Japanese classification of early carcinoma of the stomach, will present some typical cases of early gastric cancer experienced in the National Cancer Center with special reference to X-ray diagnosis.

Definition and Macroscopic Classification of Early Carcinoma of the Stomach
In 1962, researchers of gastric cancer in Japan became aware after years of study that the prognosis of stomach cancer was influenced not necessarily by the size of the cancer at the time of operation, but by the degree of carcinomatous invasion into the gastric wall. After heated and serious debate, they decided to define tumors limited to the mucosa and or submucosa as “early carcinoma of the stom-
ach". Since then, the diagnostic techniques for early gastric cancer have not only made further progress, but also rapidly spread throughout the country. As the number of early gastric cancer increased, its classification became a problem. Of various macroscopic classifications of carcinoma of the stomach, Borrmann's Classification is most widely used. Although this classification is convenient for the study of advanced carcinomas, it is not applicable to early carcinomas which have diverse macroscopic features. To cope with this problem a new macroscopic classification of early carcinoma of the stomach was presented by the Japan Gastroenterological Endoscopy Society (Chairman, Murakami).

Although some small problems are still left undecided, this classification is now being widely accepted in Japan.

**Early carcinomas of the stomach are divided into the following three basic types**
1. Protruded Type (Type I)
2. Superficial Type (Type II)
3. Excavated Type (Type III)

**The superficial type is further divided into three subtypes as follows**
1. Elevated Type (Type IIa)
2. Flat Type (Type IIb)
3. Depressed Type (Type IIc)

These Types with their incidence experienced in National Cancer Center Hospital, Tokyo, are illustrated in Table 1.

**Protruded Type (Type I):** There is an obvious protrusion into the gastric lumen.

**Superficial Type (Type II):** The unevenness of the surface is relatively inconspicuous.

**Elevated Type (Type IIa):** The surface is slightly elevated from the mucosal surface and the elevation is not more than twice the height of the normal or surrounding mucosa.

**Flat Type (Type IIb):** There is almost no recognizable elevation or depression from the normal mucosa.

**Depressed Type (Type IIc):** The depression is slight.

The difference between this type and Excavated Type (Type III) is that the dent in the former is never deeper than the muscularis mucosa.

**Excavated Type (Type III):** There is a deep excavation in the gastric wall.

This classification is valid under the following conditions;
1. The classification should be applied to early carcinoma to which Borrmann's Classification is difficult to apply.
2. Since this is purely a macroscopic classification, the histogenesis of tumors should not be considered.
3. No consideration should be given to the extent of the lesions.
4. If a carcinoma develops in a wide area and shows diverse morphological patterns, a decision must be made in accordance with the major findings. When this is not possible two or more patterns should be described one after the other, e.g. Type III + IIc.
5. When it is difficult to judge the type by macroscopic observation only, the cut surface or histological pattern of the carcinoma

<table>
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<tr>
<th>Type</th>
<th>Frequency</th>
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<tr>
<td>I</td>
<td>50</td>
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<tr>
<td>IIa</td>
<td>37</td>
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<tr>
<td>IIb</td>
<td>193</td>
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<td>IIc</td>
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<td>III</td>
<td>36</td>
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<td>Total</td>
<td>279</td>
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The results of the progress of diagnostic technique are shown in the following example. As shown in Table 2 and 3, out of 39,623 patients who received X-ray examination of the stomach at National Cancer Center Hospital in the period from May, 1962 to August, 1968, 3,721 cases were diagnosed as gastric cancer. Out of the 1,315 cases which were operated at the hospital, as many as 256 cases (19.9%) were pathologically confirmed to be early gastric cancer described above. More than 85% of the early gastric cancer cases had been correctly diagnosed before operation. The five-year survival rate of these cases was 90.3% as shown in Table 4. This number is worth-while since the same number is 69% for the cases with invasion into the muscularis propria and 20% for the cases with invasion of the serosa or subserosa. And if non-cancer death are excluded from the first group, the survival rate would rise further up to 96.6%.

This remarkable advance in X-ray diagnostics was spurred steadily by splendid progress in the gastroendoscopy, especially the gastro-camera and gastrofiberscope. The competition between two diagnostic methods succeeded in covering the dead angles each other.

At the meeting of the TNM Classification Committee of the International Union against Cancer (UICC) held in Milan, Italy, in May 1968, the above mentioned progress in Japanese diagnostics was duly acknowledged, and the conventional classification was revised. The committee adopted the proposal of Imai, the Japanese representative, and distinguished those cases which Japanese researchers call early carcinoma as Category T-1 of gastric carcinoma.

**Case Presentation**

Some of the typical cases of early gastric cancer experienced in the National Cancer Center will be presented here with some notes on each individual case.
Type I

Fig. 1 shows macroscopic findings of a protruded lesion undoubtedly with cancerous changes on the surface. Fig. 2 shows the low power photo of the section and Fig. 3 high power microscopic feature of the lesion. X-ray compression study, Fig. 4, reveals a fine and characteristic irregular figure of the surface suggesting a malignant polyp. The stalk of the polyp originating from the greater curvature side of the antrum is also demonstrated.

Type IIa

Since type IIa is a very slight elevation of the mucosa, a very careful compression study is required to demonstrate it. The lesion shown in Fig. 5, is one of the typical cases of this type located at the anterior wall of the lower gastric body near the gastric angle. Fig. 6 shows a section and Fig. 7 shows microscopic findings indicating a malignant nature of the lesion. After a careful compression, the shape and the characteristic surface of the lesion are clearly demonstrated on the film, as shown in Fig. 8. Fig. 9, shows a very small elevation of the mucosa measuring only 4 × 5 mm in diameter on the anterior wall near the lesser curvature at the gastric angle. Fig. 10 shows a section of the lesion. This lesion is clearly demonstrated on the film taken by double contrast method shown in Fig. 11. Fig. 12 is a comparative study of three major radiographical methods employed on the resected specimen of this case. The lesion is clearly seen only on the film taken by double contrast method.

Type IIb

There are several cases of flat type (IIb) early gastric cancer which can never be recognized macroscopically but which can be detected only by a thorough histological examination of the resected specimen. Lesions of this kind are occasionally as small as 2 × 1 mm in diameter, and not infrequently very large, exceeding 10 cm in diameter. A preoperative diagnosis of this type is especially difficult in small lesions. At present, our primary concern consists in the detection of this type of lesions. There are some lesions of this type combined with IIc or IIa type. This enables a precise comparison of the minute mucosal changes of this type on X-ray films and in the resected specimen.

Fig. 13 is an example of type IIc and IIb combined. As shown in the photograph and the corresponding drawing (Fig. 14 and 15), there is a very irregular and shallow cancerous erosion (IIc) at the center of the photograph. This is
Fig. 3 Histological preparation (Case 1) Papillary adenocarcinoma.

Fig. 4 Compression study (Case 1) X-ray film taken by an adequate compression method reveals a pedunculated polyp originating from the greater curvature side of the antrum. An irregularity of the surface of the head is clearly demonstrated.

Fig. 5 Early gastric cancer, Type IIa (Case 2). An irregularly shaped low mucosal elevation of 20 × 40mm in diameter is noted at the anterior wall of the gastric body near the angulus.
Fig. 6  Lateral view of the lesion (Case 2)
The height of the lesion is indicated. Carcinoma is limited in the mucosal layer.

Fig. 7  Histological preparation (Case 2)
Papillary adenocarcinoma.

Fig. 8  Compression study (Case 2)
A careful compression study succeeded in demonstrating a precise shape of the lesion.

Fig. 9  Early gastric cancer, Type IIa (Case 3)
A very small elevation of the mucosa of 4×5mm in diameter is noted on the anterior wall near the gastric angle.
identifiable with the hyperplastic mucosa and spots with irregular shape, size and outline are characteristics of IIb lesion.

Type IIc

As shown already in Table 1, the incidence of this type of early gastric cancer is the highest. This type of early cancer can be readily demonstrated by double contrast examination. Indeed this is one of the reason why so-called early gastric cancer is detected radiologically in great numbers in Japan.

Fig. 21 is a resected specimen of this type, and Fig. 22 is a cutsection of the lesion. It is quite difficult to recognize the real outline of a

Fig. 10  Lateral view of the lesion (Case 3)
Carcinoma is limited in the mucosal layer: Papillary adenocarcinoma.

Fig. 11  Double contrast radiograph (Case 3)
Double contrast radiograph reveals a characteristic lateral view of the lesion at the gastric angle.

wonderfully demonstrated on the double contrast film (Fig. 16).

The surrounding IIb lesion could not be recognized preoperatively. However, it was demonstrated on other exposures without superimposition of the shadow of duodenum (Fig. 17).

Enlarged picture of a part of the lesion corresponds to IIb is presented in Fig. 18. On thorough inspection of this film and two other films of normal area gastricae (Fig. 19) and mucosal hyperplasia (Fig. 20), one can easily recognize difference among these three features. Fine smooth, regular and very faint spots signify the normal mucosa. Relatively enlarged, expanded but smoothly outlined spots are depressed area in total without seeing the preparation. However, a well controlled double contrast radiograph clearly demonstrate the outline as shown in Fig. 23. For recognition of very fine changes of the mucosal surface of this type, double contrast radiograph is found to be far superior to a visual inspection of the resected specimen.

To explain the superiority of the double contrast radiograph, the analogy of finger prints is originally suggested by us. A finger print on the table can hardly be recognized by naked eyes, but if some powder is spread on the table it will be very easily recognized. A thin layer of barium sulfate on the mucosal surface in the
Fig. 12 Comparison study between three major radiographical methods (Case 3)
Full of barium. Double contrast radiography and mucosal study. Three major methods of radiography of the resected specimen clearly demonstrate the superiority of double contrast radiography.

Fig. 13 Early gastric cancer, Type IIc + IIb (Case 4)
An irregularly shaped very shallow erosion (IIc) is seen at the center of this figure. However, before seeing the drawing of Fig. 14 one can hardly recognize the demarcation of flat type (IIb) carcinomatous invasion, which no doctor noticed before the histological answer was presented.

Fig. 14 Drawing of the specimen (Case 4)

Fig. 15 Histological preparation (Case 4)
Mucocellular adenocarcinoma.
Fig. 16  Double contrast radiograph (Case 4)
A IIc type cancerous erosion is beautifully demonstrated by double contrast radiograph. The area corresponding to IIb should be demonstrated on the adjacent area proximal to the IIc lesion. However, IIb area, unfortunately, is superimposed with the duodenal loop in this picture.

Fig. 17  Double contrast radiograph (Case 4)
IIb area is not superimposed with the duodenum in this film, however, the demarcation of IIb is quite difficult to recognize.
double contrast radiograph serves as the powder used in distinguishing the fingerprint.

The following case is a very interesting example showing another advantage of the double contrast radiography.

Fig. 24, is a photograph of the resected specimen of this case. However, it is quite difficult to recognize the lesion, 15 × 20 mm in diameter, located at the center of the posterior wall of the lower gastric body. Fig. 25 shows photomicrograph of a section of the lesion.

Pathologists have felt a great difficulty to find out the lesion when the specimen was sent to his office. In fact, the lesion was distinctly demonstrated by the double contrast technique as shown in Fig. 26. An enlarged picture of the same lesion taken with some additional air presents characteristic features of the lesion of IIc type with several island like mucosal residue inside more beautifully (Fig. 27). The reason why double contrast radiograph be able to demonstrate such a minute change, is that a majority of the mucosal folds surrounding the lesion were distended and disappeared by air inflation into the stomach. As shown in Fig. 28, if the specimen is stretched by hand one can observe a fine lesion even on the macroscopical preparation.

The last case is type III. This type is also very difficult to diagnose, if a cancerous focus is located at the edge of benign ulcer and is so small (2 mm in diameter) as in this case.

However, a little larger cancerous focus or a III + IIc type early cancer can be diagnosed more easily. Fig. 29 shows a slight unevenness at the margin of a benign ulcer. After one month of medical treatment the ulcerative lesion shrank remarkably as shown in Fig. 30. However, unevenness of the surrounding mucosa has, on the contrary, become more conspicuous suggesting a malignancy of the lesion. Fig. 31 and Fig. 32 show gross appearance and a section at the middle of the lesion. The authors would like to emphasize the fact that the benign peptic ulcer surrounded by early gastric cancer can easily be cured by medical treatment. However the surrounding malignant lesions remains unchanged or becomes more prominent. Therefore, if a benign ulcer is once found it is quite important to follow the course until the ulcerative lesion is reduced to a complete scar.

Discussion on Radiographic Methods

Since the discovery of X-ray in 1895, methods of the X-ray diagnosis of the stomach have been making rapid progress in European countries and been refined.

Principal methods among these are the barium-filled stomach method (the stomach is filled with barium or contrast medium before X-ray photographing), the mucosal study with a small amount of barium (for photographing mucosal folds), and the compression study method. It is a common knowledge among radiologists that these methods have both merits and demeits, and, therefore, have different roles to play. A notable event in the history of early diagnosis of the carcinoma of the stomach was the heated debate at the International Congress of Gastroenterology, held in Paris in 1937, between the French school, led by R.A. Gutman, which emphasized the advantages of the barium filled stomach method, and the German school, including G.E. Kojetzny and R. Prevot, which stressed the benefit of the mucosal study with a small amount of barium. Since then, many scholars have devoted themselves to discovery of early gastric cancer by X-ray.

For its steady growth a creditable achievement of Professor W. Frik of West Germany may be highly evaluated.

In Japan, a study group led by Professor H. Shirakabe and a senior author (H.I.) have developed the double contrast method for the X-ray examination of the stomach during the period of 1953–54. This method is so unique compared with conventional methods that it is able to demonstrate minute changes of the mucosal surface.
Fig. 18  Enlarged picture of Fig. 17. (Case 4).
Enlarged picture of a part of the lesion corresponds to IIb reveals a very rough surface of the mucosa with irregular shaped, sized and outlined spots scattering over the lesion. Compare with Fig. 19 and Fig. 20.

Fig. 19  Enlarged picture of normal mucosal surface.
Fine smooth, regular and very faint spots corresponds to normal area gastricae are observed.

Fig. 20  Enlarge picture of hyperplastic mucosa.
Relatively enlarged, rather expanded but smoothly outlined spots are recognized on the hyperplastic mucosa.

Fig. 21  Early gastric cancer, Type IIc (Case 5)
A very shallow depression (erosion) is seen on the posterior wall of the stomach near the angulus.
Fig. 23 Double contrast radiograph (Case 5)
A very shallow erosion with several converging and interrupted mucosal folds is clearly demonstrated at the gastric angle. There are several radiolucent spots inside the erosion indicating island like protuberance of non-cancerous mucosal residue.

Fig. 24 Early gastric cancer, Type IIc, (Case 6)
A very shallow erosion at the center of the posterior wall of the lower gastric body is hard to be recognized.

Fig. 25 Section of the lesion (Case 6)
Adenocarcinoma mucocellulare is limited to the mucosa. Fibrous tissue with no invasion of cancer cells is noted in the submucosal layer.

Fig. 22 Lateral view of the lesion (Case 5)
Adenocarcinoma mucocellulare is limited to the mucosal layer.
Fig. 26 Double contrast radiograph (Case 6)
An irregular shaped barium flech with converging and interrupted mucosal folds is demonstrated on the posterior wall of the lower gastric body.

Fig. 27 Double contrast radiograph (Case 6)
An irregular shaped depression with several protuberance inside of the lesion is more clearly demonstrated after additional insufflation of air into the stomach.
Fig. 28  Resected specimen (Case 6)
When the specimen is stretched by hand one can observe a fine lesion in a macroscopic inspection. Compare with Fig. 27.

Fig. 29  Double contrast radiograph (Case 7)
A big ulcer niche is demonstrated at the gastric angle. Note a very fine but irregular unevenness of the surrounding mucosa closed to the oral edge of the ulcer niche (arrow)
After one month of medical treatment the ulcerative lesion shrank remarkably. However, unevenness of the surrounding has, on the contrary, become more prominent suggesting a malignancy of the lesion (arrow).

A benign ulcer is seen on the lesser curvature at the gastric angle, but, no definite sign of malignancy is noted macroscopically.

An ulcer is covered with regenerating epithelium. Differentiated adenocarcinoma is limited to the surrounded mucosa.
have been improved. Furthermore, delicate techniques for interpretation of film have also advanced under the impetus provided by the progress in the diagnostic techniques of gastro-camera. The advance of the film interpretation method has made it clear at the same time that the three conventional methods and especially the barium-filled stomach method and the compression study method, can visualize findings in more detail than so far expected if it is applied. It may be said, therefore, that the remarkable progress in the diagnostic radiology of the stomach as we see it today has been made possible by a reasonable combination of the four main methods, including the double contrast method, so that their respective merits are brought into full play.

Double contrast method

The double contrast method is explained as follows: in addition to 200 to 250 ml of barium, about the same amount of air is instilled in the stomach by inserting a gastric tube or giving a gas producing powder. As a result, a thin barium layer is formed on the mucosal surface of the stomach, creating light and shade difference since the air is inside of the stomach at the same time. By thus producing a double contrast, any small unevenness inside the stomach is beautifully depicted.

Normally some amount of air is swallowed together with barium and it has long been common knowledge that if this air is utilized, a double contrast radiograph is obtainable for the prepyloric gastric antrum. The double contrast method developed in Japan has expanded this principle. The important point is that the amount of air in the stomach is adjusted by the feeding of a necessary amount of air through gastric tube or an administration of gas producing powder. In addition, it has become possible to shift the air to any portion of the stomach and obtain the double contrast radiographs of all section, such as the gastric angulus, upper and lower gastric corpus, cardiac area and gastric fornix and anterior gastric wall, by properly changing the position of the patient.

When the stomach is empty, there are innumerable mucosal folds. These folds are photographed by the mucosal study with a small amount of barium, but minute changes, which may exist between these folds, can hard be demonstrated. By contrast, if air is sent in, the stomach is inflated to a proper extent and mucosal wrinkles are extended, making it possible to photograph even minute changes. With this method, Japanese scientists have succeeded in photographing minor lesion, which they could not even hope to discover with conventional methods, with even more distinction than when cut-off specimens are observed with naked eyes.

Detailed comparative studies of the lesions observed under the double contrast method and the conventional X-ray radiographs have shown that minute findings, which were liable to be overlooked in the past, are visualized, though slightly, in radiographs obtained by the barium-filled stomach method or the compression study method also. The merit of these two conventional methods have thus been newly appreciated. It may be said that the X-ray diagnosis of the stomach has made rapid progress by the combined use of all these methods.

The progress of diagnostic radiology of the stomach, accelerated by the development of the double contrast methods, has made a revolutionary contribution to the detection of early gastric cancer which has a high degree of curability.

Its usefulness is being demonstrated by the increasing number of such early detected cases. Furthermore, this method is applied to the mass survey for stomach cancer, which is now performed in greater numbers for the detection of hitherto unperceived gastric cancer. Its contribution to the detection of early gastric cancer is vividly shown by the statistics compiled by Ariga.

To be more specific, in 1968, more than 1,500,000 persons were covered by the mass survey throughout the country and of them,
about 0.1 to 0.2% were found to have stomach cancer. And about 30 to 50% of these cancer cases were in an early stage which is very high compared to the incidence of about 20% among the stomach cancer cases who are operated on in the hospital. This is indeed a remarkable achievement.

**Conclusion**

After a short introduction of the present state of diagnosis and treatment of gastric cancer in Japan, and of the classification of early gastric cancer, some typical X-ray findings of early gastric cancer were presented. The following points must be emphasized:

1. To detect gastric cancer in its early stage, double contrast technique of the stomach must be employed as a necessary step in the examination.

2. The combined use of other radiological techniques and endoscopic examination is also important for making a correct diagnosis.

3. In a good many cases, the double contrast technique is far superior to a macroscopic inspection of the resected specimen in recognizing very fine changes of the mucosal surface, particularly of IIc type of early gastric cancer.

4. In order to distinguish III type or III + IIc type of early gastric cancer, it is especially important to follow up cases with benign peptic ulcer in detail.

5. By comparing X-ray films of normal, hyperplastic and malignant features of mucosal surface, the possibility of radiological diagnosis of carcinoma of IIb type were discussed.

**Acknowledgements**

We are indebted to Dr. Prof. Masaru Kuru, President of the National Cancer Center, for help and encouragement, to Dr. Prof. Tadashi Murakami and Dr. Prof. Hikoo Shirakabe, for their invaluable suggestions during our study, to members of the Endoscopy Department and Pathology Department for help with the histological studies.

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