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特別掲載

Double Contrast Radiography of the Colon and Rectum by Means of the Universal Gyroscopic X-Ray Television Apparatus

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ジャイロ式万能X線テレビ装置による大腸二重造影法

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黒川、西山らが考案したジャイロ式万能X線テレビ装置(東芝製 Model DT-UG)を用いて大腸の二重造影法をおこない、その診断成績から本装置の特徴について考察した。

1972年1月から1973年6月までの1年6カ月間に1,000例について、16枚撮影法による onestage method をルーチン検査として施行した結果、直腸癌および結腸癌60例(早期癌5例をふくむ)、ポリープおよびポリポージス 114例、憩室疾患41例、潰瘍性大腸炎6例、結核9例、Behçet 氏病2例、合計 232例(23.2%)に器質的な異常所見

が発見された。以上のような診断成績を基にしてジャイロ式万能X線テレビ装置の特徴を考察し、

- (1) 従来、二重造影法の盲点であった直腸、S状結腸、盲腸、上行結腸が簡単に描写できる、
- (2) 大腸各部位の盲点を解消するとともに、各部位の撮影体位とフィルム枚数(16枚撮影法)の合理的な組み合わせにより短時間に検査ができる、
- (3) 大腸の隆起性病変、とくにポリープが有茎性か無茎性かの判定が簡単にできる、などの点で、本装置は従来の装置よりもはるかに勝れた診断能を有することが確かめられた。

The double contrast radiography of the colon and rectum, which was first originated by Fischer in 1923, has been newly established by Welin in 1958 as the Malmö technique. Welin emphasized the necessity of taking double contrast radiographs in a certain sequence of x-ray exposure combined with various positions of the patient. In 1969, Brown reported "the direct air contrast colon examination" as a rapid and highly diagnostic procedure. His method has been accepted, because it is performed

in a relatively short time without evacuation of contrast medium. However, there still remains some technical difficulty in obtaining the entire colon and rectum as a double contrast image due to the anatomical complexity of the organ, although such modifications of the double contrast radiography by Welin and Brown have brought a marked improvement in the diagnosis of colonic pathology. Our experience until present has shown undoubtedly that polyps of the rectum, sigmoid colon, ascending colon, and cecum escape detection unless the double contrast radiography is performed completely in these portions.

In 1969, Kurokawa and Nishiyama devised a machine named "The Universal Gyroscopic X-ray Television Apparatus" (UGTV) for the purpose of getting a wider diagnostic area of the stomach that could not be visualized by a conventional fluoroscopic table. This machine was manufactured by Tokyo Shibaura Electric Co. Ltd. (Toshiba) as Model DT-UG (Fig. 1) Although this machine was originally

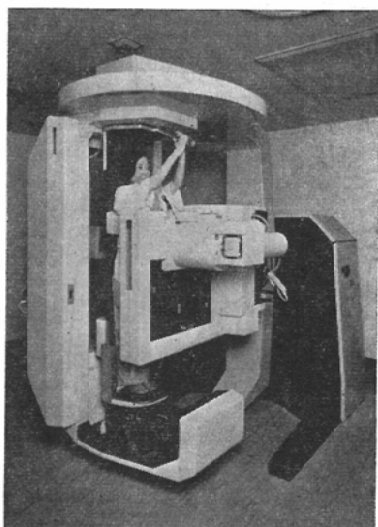


Fig. 1. Universal gyroscopic X-Ray television apparatus (Toshiba, Model DT-UG).

devised for the improvement of stomach examination, we have been trying to make use of it for the examination of the colon and rectum since the second machine manufactured experimentally was set up in our hospital in 1971.

After several months of experimental study, it has been used for the routine examination of the colon and rectum under a fixed sequence of x-ray exposure by double contrast radiography. In the period of 1.5 years from January 1972 to June 1973, 1,024 double contrast examinations (1,000 cases) of the colon and rectum were made, and not only an improvement of the diagnostic result but also some new aspects of this machine that exceeded the function of a conventional one were observed. This paper deals with the result of these 1,024 examinations (1,000 cases) by means of The Universal Gyroscopic X-Ray Television Apparatus, in addition to its new aspects.

Functions and Features of the Universal Gyroscopic X-Ray Television

Apparatus (Toshiba Model DT-UG)

The Universal Gyroscopic X-Ray Television Apparatus (UGTV) can be tilted in three positions; standing, lying and upside-down position. Standing position and lying position are similarly taken with a conventional fluoroscopic table, but it permits only a 15° tilting to the head-down position. On the other hand, the upside-down position is made possible with the use of the UGTV. Moreover, this machine has two new functions in addition to the performance of the upside-down position. These are "patient rolling" (P) and "main rotation" (M). The patient rolling (P) means, as illustrated in Fig. 2,

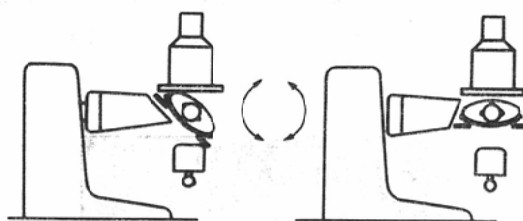


Fig. 2. Patient rolling ($\pm 90^\circ$)

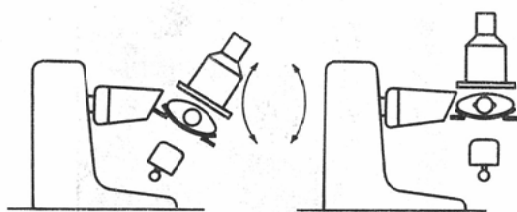


Fig. 3. Main rotation $(-)\ 90^\circ \sim (+)\ 360^\circ$

the rolling of only the patient to $\pm 90^\circ$ either way, which enables the patient to take an oblique to lateral position. The main rotation (M) is a movement of the whole system including the X-Ray tube, the patient, and the image intensifier (I, I) about the body axis of the patient, as illustrated in Fig. 3. Its rotational range is from $+360^\circ$ (clockwise) to -90° (anti-clockwise) seen from head of the patient. By this procedure postero-anterior exposure is made in every direction. Thus, an appropriate combination of the tilting (T), patient rolling (P) and main rotation (M) makes it possible to perform "rotation-multidirection radiography" in double contrast examination of the colon and rectum.

Sequence of X-Ray Exposure in the Routine Double Contrast

Radiography of the Colon and Rectum

As mentioned above, the UGTV was devised in order to make a better examination of the stomach than by the conventional apparatus. During the period of several months since it was set up in our hospital, it was used only for examination of the stomach. Later, double contrast radiography of the colon and rectum was begun experimentally for a few patients a day. From this experimental study, we have made a certain sequence of x-ray exposures of the double contrast radiography for the routine

Table 1. Sequence of X-Ray exposure in the routine double contrast examination
of the colon and rectum with the UGTV

No.	Portion	Tilting	Patient rolling	Main rotation	Position
1.	R.S.	0°	0°	0°	Supine frontal
2.	R.S.	0°	-20°~30°	0°	Supine R.A.O.
3.	R.S.D.	-90°	0°	-90°	Upside-down
4.	R.S.D.	-90°	-20°~30°	-90° R.A.O.
5.	T.D.	+90°	0°	+90°	Upright frontal
6.	T.D.	+90°	+20°~50°	+90°	Upright L.A.O.
7.	D.T.S.	0°	+10°	+90°	L. Horiz. beam
8.	D.S.	0°	±20°~30°	+90° R.A.O.
9.	T.(D)	0°	+10°~20°	0°	Supine L.A.O.
10.	T.(A)	0°	-20°~30°	0°	Supine R.A.O.
11.	C.A.	-90°	0°	-90°	Upside-down
12.	C.A.	-90°	-20°~30°	-90° R.A.O.
13.	A.T.	+90°	0°	-90°	Upright frontal
14.	A.T.	+90°	-20°~50°	-90° R.A.O.
15.	A.C.T.	0°	0°	-90°	R. Horiz. beam
16.	A.C.T.	0°	-20°~30°	-90° R.A.O.

R: Rectum. S: Sigmoid colon. D: Descending colon. T: Transverse colon. A: Ascending colon. C: Cecum.

practice, as shown in Table 1. The new expression of positioning with the UGTV is made in the order of tilting (T), patient rolling (P) and main rotation (M) in degree by putting on + (plus) for clockwise movement and - (minus) for anti-clockwise movement. The standard position is indicated by the expression 0°.0°.0° in T.P.M., which corresponds to the supine, frontal position in the conventional positioning of a patient.

The degree of +90° in main rotation (M) corresponds to the right decubitus position with the left horizontal beam and that of -90° vice versa. The examination is commenced with double contrast radiography from the distal to proximal colon, and sixteen sheets of film are used for one routine ex-

amination. The 16-film method was considered for the purpose of taking the double contrast radiography of the same portion of the colon and rectum at least in three different directions. The average time for one examination is 15 minutes.

Preparation for the Routine Double Contrast Examination of the Colon and Rectum

Low-fat, low-residue diet is prescribed for supper for two days prior to the examination and saline type laxative (magnesium citrate) and contact-type evacuant (Phenilax) are used the night before the examination without castor oil. Sixty ml of handy type glycerol enema is used at 7.00 am in the morning of the examination.

The supper on the two days prior to the examination is designed to be about 800 cal, with 6.0 g of fat and 0.8 g of fiber content. The total calory of the diet on the day before the examination is designed to be 1,000 cal, with 3.0 g of fat and 1.0 g of fiber content.

Method for Double Contrast Radiography of the Colon and Rectum

The uniformity in the method of the double contrast radiography was maintained from the beginning of this study. As the first step of the examination, the contrast medium is injected until the point just over the splenic flexure with complete filling. Then, a column of the contrast medium is moved until the cecum by slow insufflation with air by a pumping tube and insufflated until the entire colon is distended sufficiently for the double contrast radiography. The contrast medium in the rectum is absorbed into a suction bottle by negative pressure. Segmental photography of the colon and rectum is performed in the order shown in Table 1. Concentration of the contrast medium used is 65% w/v.

Result of Diagnosis

In the period of 1.5 years from January 1972 to June 1973, 1,024 examinations for 1,000 cases were performed. The result of diagnosis in this period is shown in Table 2, functional disorders like irritable colon syndrome being excluded. The number of abnormality diagnosed is 232 cases, which comprise

Table 2. Cases of the colon and rectum discovered with UGTV

*Carcinoma		60 Cases
Rectum	22	
Sigmoid	23	
Descending	1	
Transverse	5	
Cecum	9	
*Polyp and Polyposis		114 Cases
Polyp and Polyps (until 5)	100	
Polyposis	5	
Familial Polyposis	9	
*Diverticular Disease		41 Cases
*Ulcerative Colitis		6 Cases
*Tuberculosis		9 Cases
*Behçet's Disease		2 Cases

Jan. 1972—Jun. 1973

Cancer Institute Hospital

23.2% of all patients examined. Carcinoma was discovered in 60 cases, comprising 6%, and endoscopic examination confirmed the diagnosis in 59 cases. In only one case diagnosed as carcinoma of the cecum, endoscopy was negative and re-examination by double contrast radiography confirmed the diagnosis of ileo-cecal deformity caused by visceral adhesion after gastrectomy. Early carcinoma was discovered in 5 cases and this was confirmed histologically.

Polyp and polyposis were discovered in 114 cases (11.4%), including 100 cases of single to multiple polyps, 5 cases of non-familial polyposis, and 9 cases of familial polyposis. The location of polyp and

Table 3. Location of discovered polyps

Rectum	28 Cases
Sigmoid	30 Cases
Descending	12 Cases
Transverse	14 Cases
Ascending	11 Cases
Cecum	5 Cases

Total 100 Cases

Jan. 1972—Jun. 1973

Cancer Institute Hospital

Table 4. Comparison of X-Ray and endoscopy in diagnosis of polyp

X-Ray \ Endosc.	Positive	Negative
Positive	28	1
Negative	18	0

Jan. 1972—Jun. 1973

Cancer Institute Hospital

polyps in these 100 cases is listed in Table 3. Of these, x-ray diagnosis was compared with that of endoscopy in 47 cases which were examined by endoscopy, as shown in Table 4. One polyp could not be visualized by the double contrast radiography and was discovered by endoscopy. On the other hand, endoscopy was unsuccessful in visualizing 18 cases which were diagnosed as polyp by radiography.

Diverticular disease, including 5 cases of diverticulitis, was discovered in 41 cases, comprising 4.1%. Tuberculosis of the ascending colon and ileo-cecal region was discovered in 9 cases, comprising 0.9%. Two cases of ileo-cecal ulcer were diagnosed as abdominal Behcet's disease.

Case Presentation

Case 1. Rectum, early carcinoma (Figs. 4 and 5)

The positioning of the UGTV was done as shown in the illustration of Fig. 4 in order to remove the excess of contrast medium from the rectum to the proximal colon in this case. A frontal shape of a polypoid lesion is visualized (Fig. 5). Histological examination revealed that cancer was limited to the submucosal layer (early carcinoma).

Case 2. Sigmoid colon, polypoid cancer, advanced (Figs. 6 and 7)

The positioning of the UGTV was controlled in order that the lesion was hanging down in the colonic

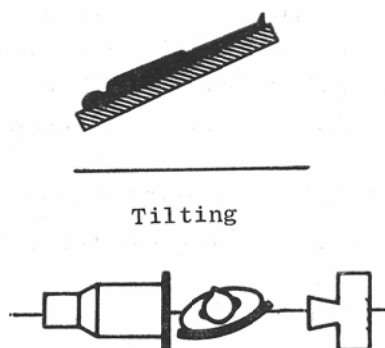


Fig. 4. Photographic positioning of case 1.
Main rotation and patient rolling

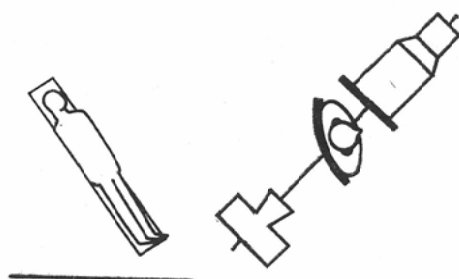
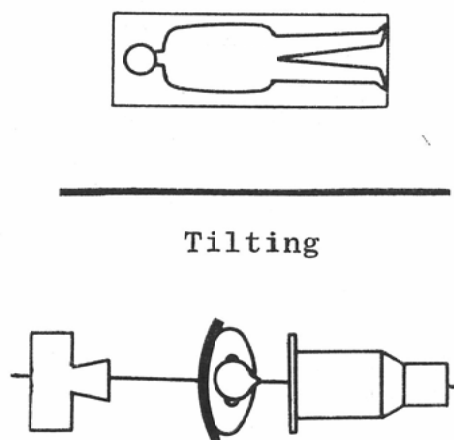


Fig. 6. Photographic positioning of case 2.
Tilting patient rolling and main Rotation



Tilting

Main Rotation

Fig. 8. Photographic positioning of case 3

lumen, as shown in the illustration of Fig. 6. The lesion looks like a tall sessile tumor (Fig. 7). Histological examination revealed slight involvement of the muscularis propria (advanced cancer).

Case 3. Descending colon, familial polyposis (Figs. 8 and 9)

This image was taken in the positioning No. 7 as shown in Table 1 (Fig. 8). In the positioning No. 6, the contrast medium retained in the upper descending colon flew to the transverse colon and that in the lower descending colon to the sigmoid colon. Then, the machine was placed to the left horizontal beam (No. 7, T.P.M.: 0, +10°, +90°). There is no retention of the contrast medium in the descending colon, enabling clear visualization of the whole descending colon as a double contrast image (Fig. 9).

Case 4. Transverse colon, ulcerative colitis (Fig. 10)

This image was taken in the positioning No. 13 which is equal to the supine, right anterior oblique

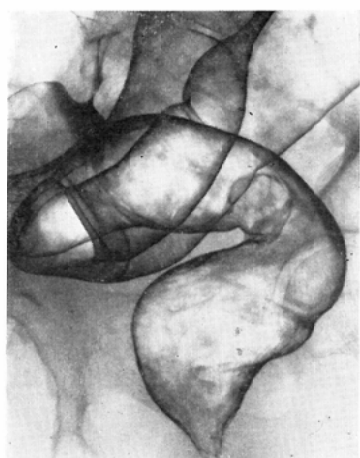


Fig. 5. Case 1. Early carcinoma of the rectum.

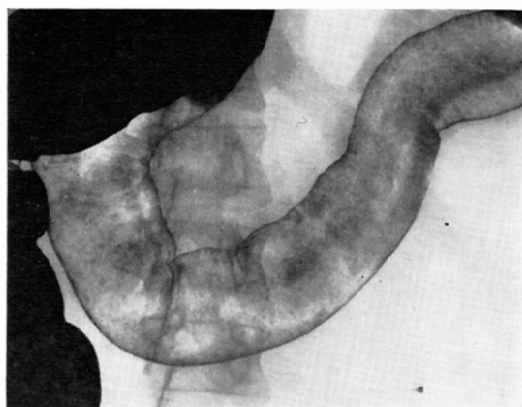


Fig. 10. Case 4. Ulcerative colitis.

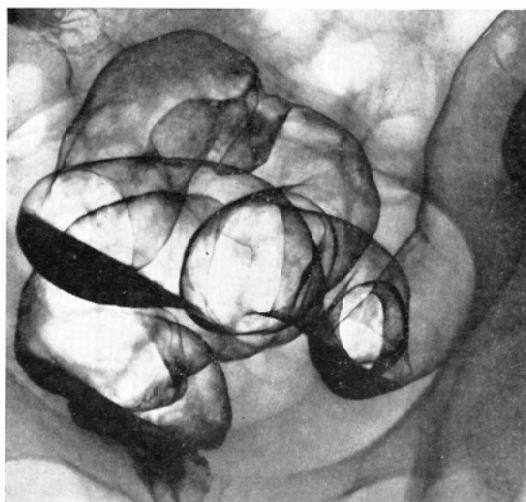


Fig. 7. Case 2. Polypoid carcinoma of the sigmoid colon, advanced.

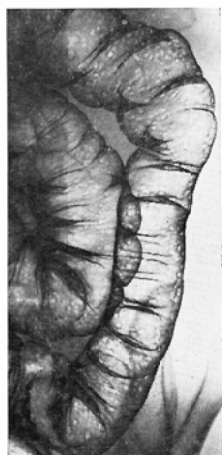


Fig. 9. Case 3. Familial polyposis

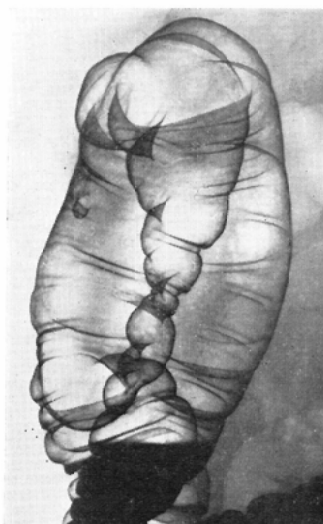


Fig. 11. Case 5. Small diverticulum of the ascending colon.

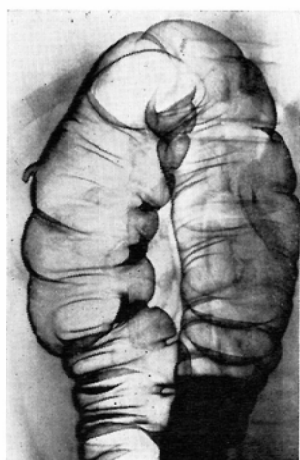


Fig. 12. Case 5. Small diverticulum of the ascending colon.

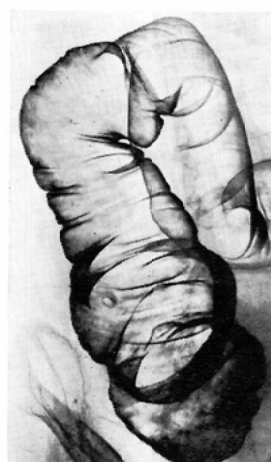


Fig. 17. Case 7. Small sessile polyp of the ascending colon.

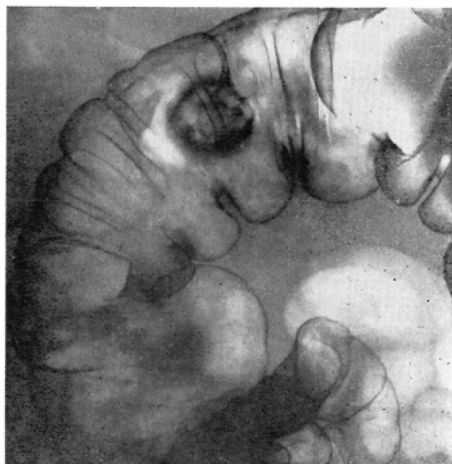


Fig. 13. Case 6. Pedunculated polyp of the ascending colon.



Fig. 15. Case 6. Pedunculated polyp of the ascending colon.

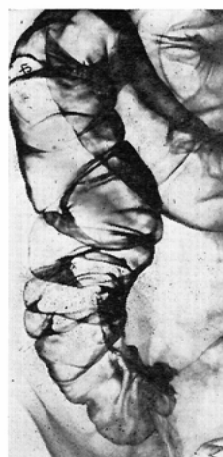


Fig. 19. Case 8. Carcinoma of the ileo-cecal region

position with a conventional fluoroscopic table (Fig. 10). Fine mottled pattern of the mucosa reveals numerous tiny ulcerations. The upper margin of the transverse colon is deformed with complete disappearance of the haustrations.

Case 5. Ascending colon, small diverticulum (Figs. 11 and 12)

The image of Fig. 11 was taken in the positioning No. 13 which is equal to the upright, frontal position with a conventional fluoroscopic table. In this image a small diverticulum or a polyp is suggested. Then, the image of Fig. 12 was taken in the order of No. 14 which is equal to the upright, right anterior oblique position. A profile view of the lesion led to the diagnosis of a small diverticulum.

Case 6. Ascending colon, pedunculated polyp (Figs. 13, 14, and 15)

A polypoid lesion was discovered by fluoroscopy in the positioning No. 10. A short stalk is visualized in Fig. 13. Then, the machine was controlled in order that the maximum length of the stalk would be demonstrated, and in the positioning shown in Fig. 14, the polyp hang down in the lumen of the ascending colon with the maximum length of the stalk. The diagnosis of a pedunculated polyp was made easily (Fig. 15).

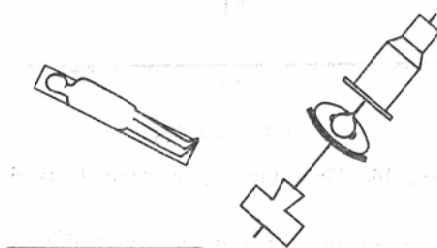
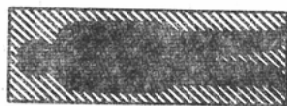
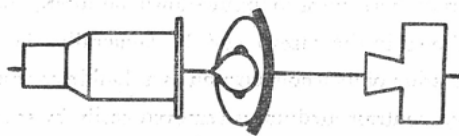


Fig. 14. Photographic positioning of case 6.
Tilting, patient rolling and main rotation



Tilting



Main Rotation

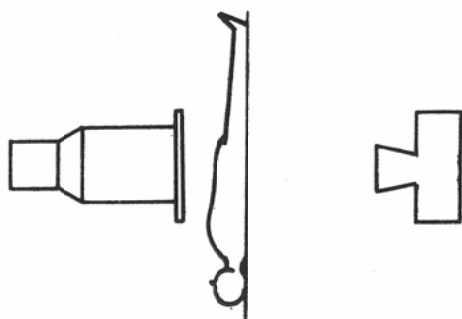
Fig. 16. Photographic positioning of case 7

Case 7. Ascending colon, small sessile polyp (Figs. 16 and 17)

The image of Fig. 17 was taken in the positioning No. 15 which was equal to the left decubitus position with the right horizontal beam as shown in Fig. 16. A very small sessile polyp was visualized and was confirmed by endoscopy.

Case 8. Cecum, carcinoma of the ileo-cecal region (Figs. 18 and 19)

This image was taken in the positioning No. 11. The patient was brought to the upside-down po-



Tilting

Fig. 18. Photographic positioning of case 8

sition (Fig. 18). A tumor shadow was visualized at the ileo-cecal region with a depressed sign of the margin and the haustral distance around the lesion is shortened (Fig. 19).

Discussion

Although the double contrast radiography of the colon and rectum, which was improved by Welin and Brown, has brought a marked development of the diagnosis of colonic diseases, it has not been satisfactory because of the technical difficulty that arises in obtaining details of the rectum, sigmoid, ascending colon, and cecum due to retention of the contrast medium. For this reason, it is usually accepted that the double contrast radiography has not been always useful for all cases. With the Universal Gyroscopic X-Ray Television Apparatus (UGTV), however, such difficulty has been solved completely. An appropriate combination of tilting, patient rolling and main rotation has made it possible to take a double contrast image of every portion of the colon and rectum, regardless of individual difference in colonic anatomy. Especially, the double contrast radiography of the rectum and sigmoid colon is obtained easily by tilting the machine from horizontal to upside-down position, together with an adequate positioning by main rotation, as shown in the cases 1 and 2. Generally, the retained contrast medium in the rectum disturbs clear visualization of its whole portion as a double contrast image with a conventional fluoroscopic table. The retained contrast medium is removed easily by setting the upside-down position with the UGTV. In this position, the contrast medium is collected in the angle of mid-sigmoid colon and majority of it flows to the descending colon by combined movement of anti-clockwise main rotation and clockwise tilting from the upside-down to horizontal position. There have been many polyps of

the rectum and sigmoid colon that could not be demonstrated on a double contrast image with a conventional fluoroscopic table in spite of its endoscopic evidence, but the UGTV has reduced the possibility that small polyps escape detection to the minimum.

It has been also very difficult to get a double contrast image of the ascending colon and cecum by a conventional fluoroscopic table. Usually, majority of the contrast medium, once it enters the ascending colon and cecum, cannot be moved to the transverse colon by postural change, interfering with clear visualization of that portion. With the UGTV, however, only the upside-down position is sufficient to get double contrast image of this portion. When an excess of contrast medium is collected at the hepatic flexure in this portion the main rotation is made to -90° . Then, the tilting is returned to the horizontal position (T.P.M.: $-90^\circ, 0^\circ, 0^\circ$. $-90^\circ, 0^\circ, 0^\circ$. $0^\circ, -90^\circ, -90^\circ$). By this procedure, all the contrast medium in the cecum and ascending colon is moved to the transverse colon. Thus, a complete double contrast image of the right side colon can be made. When too much of the contrast medium is retained in this portion, the above-mentioned procedure is repeated two or three times. Generally, a relatively large amount of the contrast medium produces better coating to the mucosa of the cecum and ascending colon, and consequently increases discovery of small lesions like cases 5 and 7. By the methods of Brown as well as of Welin, the double contrast radiography of the cecum and ascending colon is sometimes unsuccessful owing to the lack of contrast medium.

As Welin stated, the principles of the modern diagnostic radiology of the colon and rectum lies in film-diagnosis by a certain sequence of x-ray exposures in various positions. An examination of the colon and rectum by the double contrast radiography should cover all the portions by an adequate number of films. With a conventional apparatus, however, there has been much difficulty in obtaining double contrast images of the entire colon and rectum, because the contrast medium cannot be moved only by a slight degree of tilting and manual postural change. Also, it takes much time for one examination. Now, with the UGTV a rational combination of x-ray exposure and postural change has become possible, making the examination time shorter. As shown in Table 1, 16-film method was employed in our study and the average time for one examination was 15 minutes. In this method segmental photography is performed from the rectum to the cecum in order to cover one segment of the colon and rectum at least in three different directions. It is anticipated to judge an existence of a lesion in doubt by various images of the same portion and moreover, to give a lesion much possibility of being projected in different angles as shown in the illustrations of case 5.

As indicated in cases 1, 2 and 6, it is very important to judge whether a lesion is sessile or pedunculated in diagnosis of polypoid lesions. With a conventional fluoroscopic table, we have been used to seeing such an image as that of Fig. 13, but it may not be sufficient for the detailed diagnosis of the nature of the polyp. A visualization of such an exact shape as seen on a resected specimen is required for strict judgement.

Fig. 14 (case 6) reveals the exact shape of a pedunculated polyp, including even the correct length of the stalk. Once a polypoid lesion is discovered in the routine examination, its whole aspect should be scrutinized. A pedunculated polyp will hang down in the colonic lumen by a combined movement of tilting and main rotation as shown in case 6. Case 2 was also demonstrated by the same procedure as in case 6. Thus, the UGTV is very effective for the detailed analysis of polypoid lesions.

Summary

A result is presented for the double contrast radiography of the colon and rectum by the use of The Universal Gyroscopic X-Ray Television Apparatus which was devised by Kurokawa and Nishiyama. Of the total number of 1,000 patients examined in the period of 1.5 years from January 1972 to June 1973, 232 cases (23.2%) were diagnosed as abnormal, including 60 cases of carcinoma (6%) and 114 cases of polyp and polyposis (11.4%). Diverticular disease was discovered in 41 cases (4.1%), including 5 cases of diverticulitis. Tuberculosis of the ascending colon and ileo-cecal region was discovered in 9 cases (0.9%) and abdominal Behcet's disease (ileocecal ulcer) in 2 cases (0.2%).

The Universal Gyroscopic X-Ray Television Apparatus was proved to be effective for the double contrast radiography of the colon and rectum in the following three points.

(1) Double contrast radiography of the entire colon and rectum can be obtained by a certain combination of tilting, patient rolling and main rotation; (2) an adequate sequence of x-ray exposure for the routine examination can be carried out easily by the segmental photography from the rectum to the cecum in a short time, and (3) it is very useful for the diagnosis of whether a polypoid lesion is sessile or pedunculated. Especially, a pedunculated polyp is demonstrated in the state of hanging down in the colonic lumen by the use of this machine.

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