

# Development of Two Oral Contrast Materials for CT Evaluation of the Esophagus

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**Background:** Computed tomography (CT) is a widely available modality in evaluating benign and malignant diseases of the esophagus. To date, there is no substantial consensus on the optimal and widely available method for opacifying the esophageal lumen exists for CT.

**Objective:** The present study was performed for complete and continuous opacification of the esophagus using two developed oral contrast materials and a commercial barium paste formulated for CT.

**Material and Method:** One hundred and seven adult patients were sent for spiral routine CT scan of the chest (Light speed plus; General Electric Medical System, Milwaukee, Wis., USA) to evaluate variety of clinical conditions at Ramathibodi Hospital. They were divided into three groups. Two developed oral contrast materials, 1.5%(wt/vol) carboxy-methyl cellulose sodium paste containing 2%(wt/vol) barium sulfate and 5.5%(wt/vol) potato starch containing 2%(wt/vol) barium sulfate, and a commercial barium paste were randomly administered. Data collection and analysis of the CT findings were performed double blindly.

**Results:** The patients undergoing CT scan of the chest were performed with one of the oral contrast material. No streak artifact was present in any of the CT slices. Of the grade 1, contrast present without luminal distension and grade 2, contrast present with luminal distension, 1.5% CMC containing 2% barium sulfate was opacified in 36.48% and 17.45%, respectively. Opacification with 5.5% starch containing 2% barium sulfate was of 36.41% and 19.71% while that of 3% commercial barium paste was of 36.68% and 27.54%, respectively. Acceptable taste was also achieved. However, mild to moderate difficulty in swallowing occurred in 35% with no medication or intervention needed.

**Conclusion:** All oral contrast materials tested were less continuous and did not opacified the esophageal lumen as much when compared with the prior studies [8-11]. However, acceptable taste, only mild to moderate difficulty in swallowing during the procedure, and significantly cheaper cost enable them to be used in selected cases in CT scan of the neck, chest, and upper abdomen for clarification of the problem areas.

**Keywords:** Contrast material, Esophagus, Computed tomography

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Several available modalities to detect the esophageal disease vary considerably in effectiveness, cost, and degree of invasiveness. Barium study is useful in evaluating esophageal morphology and motility. However, this technique requires that the patient be able to stand upright, which may not be possible with patients who are debilitated. Also noted for bulkier obstructive lesions, an air-contrast technique may not be possible. Additionally, a detailed mucosal examination may not achieve distal to the obstruction.

Esophageal endoscopy and endoscopic ultrasonography (EUS) permit direct inspection and biopsy of the esophageal mucosa for histological diagnosis. However, limitation includes an inability to pass the malignant stricture with the transducer. While positron-emission tomography (PET) offers unique information for staging esophageal carcinoma, it has limitations in spatial resolution and cost. In addition, they may not

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be able to detect subcentimeter foci of tumor metabolism. For esophageal cancer staging, magnetic resonance imaging (MRI) is not superior to Computed tomography (CT)<sup>(1)</sup>.

CT is a non-invasive and widely available method. It is useful in evaluating benign and malignant diseases of the esophagus. It can delineate wall thickness, mediastinal involvement, adjacent lymphadenopathy, and distant metastasis because of its cross-sectional imaging capability and superior sensitivity to contrast materials. Furthermore, many investigators recommend a routine CT examination before treatment planning<sup>(2-5)</sup>. Pre-operative CT of the esophagus is usually performed to determine the resectability of the tumor and avoid unnecessary surgery<sup>(6)</sup>.

Esophageal wall thickening is the earliest CT manifestation of the esophageal carcinoma<sup>(2)</sup>. However, many benign conditions as well as involvement of the esophagus from other malignancies can cause esophageal wall thickening. In addition, the collapsed esophagus can occasionally lead to the false diagnosis of esophageal wall thickening<sup>(7)</sup>. A pseudo-mass at the gastroesophageal junction may be commonly seen, but it will disappear with distension and decubitus scanning<sup>(8)</sup>.

The importance of pinpointing the position of the esophagus and its lumen on CT images is in detecting the presence and extent of a variety of the esophageal disorders. The mediastinal lymphadenopathy or an esophagus involved by lung carcinoma may show contralateral displacement or partial obstruction. When the esophagus is not distended with contrast materials, a hiatal hernia can be confused with a mass or tumor.

To date, there is still no substantial consensus on the optimal method for opacifying the esophageal lumen for CT. Although in the normal esophagus up to 60% of images have air within them, the presence of air would be expected to be less in extrinsic disease because of mass effect<sup>(9)</sup>. Water-soluble contrast materials or diluted barium mixtures used in abdominal CT do not provide adequate opacification of the esophagus because of poor coating and rapid removal by peristalsis. In addition, barium mixtures developed specifically for esophageal coating on conventional x-ray studies are frequently too radiopaque and they produce streak artifacts<sup>(9-11)</sup>.

This was a prospective study on the efficacy in optimal opacification of the esophageal lumen for CT study. To create a specific contrast material for the esophagus, we used three available contrast agents:

- 1.5% (wt/vol) carboxy-methyl cellulose sodium paste containing 2% (wt/vol) barium sulfate
- 5.5% (wt/vol) potato starch containing 2% (wt/vol) barium sulfate
- 3% (wt/wt) commercial barium paste formulated for CT<sup>(9-11)</sup>

Carboxy-methyl cellulose sodium is a mild laxative, ethically approved in Japan and without problems with the U.S. Food and Drug Administration. It is widely available<sup>(11)</sup>. Potato starch is an ordinary food additive<sup>(12)</sup>.

A low-density barium sulfate preparation was used in CT examination of the abdomen and the pelvis. A clinical study of Higashi T et al<sup>(11,13)</sup> showed that the 2.0% preparation tends to show better contrast and a better filling rate for the upper abdominal organs than the 1.5% preparation.

A 3% (wt/wt) commercial barium paste is a low-density commercial barium paste formulated for CT.

## Objective

The objectives of the present study were to compare the efficacy of two developed oral contrast materials and a commercial barium paste for esophageal opacification in computed tomography examination at Ramathibodi Hospital, and to evaluate acute complication and taste of the contrast materials in routine spiral CT scan of the chest.

## Material and Method

### Materials

1. Thirty milliliters of three kinds of oral contrast materials were used:

- 1.5% (wt/vol) carboxy-methyl cellulose sodium paste containing 2% (wt/vol) barium sulfate
- 5.5% (wt/vol) potato starch containing 2% (wt/vol) barium sulfate
- 3% (wt/wt) commercial barium paste formulated for CT scan

2. Patient instruction and consent form in receiving an oral contrast material before CT examination

3. Data collection form

4. Imaging slices in axial plain and enhanced CT of the chest (soft tissue window)

### Research design

Descriptive study with prospective data collection

### Place of study

Advanced Diagnostic Imaging and Image-

guided Minimal Invasive Therapy Center (AIMC), Sirikit Medical Center, Faculty of Medicine, Ramathibodi Hospital

#### **Duration of study**

From July to November 2004.

#### **Inclusion criteria**

Patients who were allowed to enter the study were 18 years old and over, cooperative out-patients, who requested routine spiral CT scan of the chest at AIMC, Sirikit Medical Center, Faculty of Medicine, Ramathibodi Hospital between July and November 2004.

#### **Exclusion criteria**

1. Those with a previous history of drug or seafood allergy, asthma or contrast reaction
2. Those with risk for aspiration
3. Those with a history of significant esophageal obstruction
4. Those with prior esophageal surgery
5. Those having severe impairment of renal function
6. Those refusing research enrollment

#### **Methods**

The Ethic and Committee of the Hospital had given approval to the research protocol.

After having given informed consent, patients who were sent for routine spiral CT scan of the chest for variety of clinical conditions were administered 30 ml of the oral contrast material while they were lying in the supine position on the CT table prior to start of the scan. The type of contrast material given to each patient was decided according to a predetermined code using block randomization. The patients were instructed to limit swallowing until the examination was completed. Intravenous injection of iodinated contrast was routinely performed. Imaging was performed with a multidetector CT scanner (Light speed plus; General Electric Medical System, Milwaukee, Wis., USA). Slices were obtained from hypopharynx to the gastric fundus level. The table moving rate of CT scanner was 10 mm/sec in plain and 3.75 mm/sec in intravenous contrast study after a 45 second delay. The total scanning time was approximately 60 seconds.

For the purposes of analysis, the esophagus was divided into three segments:

· The cervical segment: hypopharynx to upper margin of sternum

· The thoracic segment: upper margin of sternum to diaphragmatic hiatus

· The intra-abdominal segment: diaphragmatic hiatus to cardia

Each slice within these segments was evaluated for the amount of contrast material within the esophagus. The opacification was graded on a scale of 0-2;

0 = no contrast

1 = contrast present without luminal distension

2 = contrast present with luminal distension

Distension of the lumen was measured from the inner border of one wall to the inner border of the opposing wall in cross section of the esophagus and divided by two. Each lumen with more than one-half of the lines between both borders indicated luminal distension<sup>(13)</sup>.

The radiologist evaluated the efficacy of esophageal luminal opacification blindly. For each of the three levels, the total number of images obtained through each segment and the total number of images containing visible contrast material in the esophageal lumen were recorded.

#### **Evaluation of patient tolerance and taste**

All patients were interviewed after the CT examination in a non-suggestive method regarding subjective acceptance and acute adverse effects. The taste of the contrast materials was recorded in five grades: impossible to swallow, awful taste but can drink, moderate taste, good taste, and excellent taste or no problem to swallow. Adverse effects were recorded as mild, moderate, and severe. Mild adverse effect was defined as transient and no medication needed. Moderate form needed some medication or intervention. Severe form implied that patients needed urgency or emergency management.

#### **Statistical analysis**

Discrete variables (e.g. sex, adverse effects) were analyzed by number and percent.

Continuous variables (e.g. age, weight, height, taste) were analyzed for defining the patient's characteristics, using mean and standard deviation.

The outcomes were collected and analyzed separately according to each type of the contrast materials, using Pearson chi-square test. A p-value of less than 0.05 was considered significant difference.

#### **Results**

One hundred and seven patients were enrolled

in the present study, 55 males and 52 females, ranging in age from 18 years to 80 years (mean age,  $56.40 \pm 13.03$  years). The mean weight and height of the patients were  $59.16 \pm 11.50$  kilograms and  $159.59 \pm 8.63$  centimeters, respectively. According to organ of interest in the requested data form, 90 patients (84.11%) were classified as lung/tracheobronchial tree, 16 patients (14.95%) mediastinum and one patient (0.93%) bony structure, whereas none was classified as esophagus. The details are shown in Table 1.

Randomly, the patients were classified as CMC+Ba, 1.5% (wt/vol) carboxy-methyl cellulose sodium paste containing 2% (wt/vol) barium sulfate; Starch+Ba, 5.5% (wt/vol) potato starch containing 2% (wt/vol) barium sulfate; and Commercial, 3% (wt/wt) commercial barium paste formulated for CT. The number of the patients is shown in Table 2.

Twelve thousand twenty-seven slices were evaluated from 107 patients. No streak artifact from the esophageal contrast materials in any of the examina-

tion was evaluated. The degree of contrast opacification was classified as grade 0 (no contrast), grade 1 (contrast present without luminal distension) shown in Fig. 1, and grade 2 (contrast present with luminal distension) as shown as Fig. 2 and 3, with p-value of less than 0.005. The degree of opacification is shown in Table 3.

For the purpose of analysis, the degrees of esophageal opacification were divided into three segments, cervical, thoracic, and intra-abdominal segments, respectively as shown in Tables 4, 5 and 6.

Abnormal thickening of the esophageal wall was detected in a patient requested to evaluate multiple pulmonary nodules with primary lung cancer and clinical progressive dysphagia, as shown in Fig. 4. Prior CT scan of the chest showed soft tissue density at the area of the upper esophagus, questionable lymph node enlargement, or esophageal lesion. Barium swallow had neither mucosal destruction nor obstruction of the esophagus. The patient was given the diagnosis as metastatic lung cancer to the thoracic esophagus and to be treated.

Taste of the contrast materials was recorded in five groups. One patient stated that it was impossible to swallow. Seven patients stated that it had awful taste. Thirty-three patients stated that it had moderate taste. The remainder 66 patients stated that the taste was either good or excellent. The number of the patients' complaint for each contrast material is shown in Table 7.

Twenty-eight patients (26.17%) had mild difficulty in swallowing and nine patients (8.41%) had moderate degree. No patient presented severe degree of swallowing difficulty during the present study. The overall patients with moderate degree improved after observation at AIMC. No medical treatment was noted. No chest discomfort occurred in any patient. The details are shown in Table 8.

## Discussion

CT is a non-invasive and widely available modality to detect the esophageal disease that has

**Table 1.** Number of the patients according to organ of interest

| Organ of interest          | Number | Percent (%) |
|----------------------------|--------|-------------|
| Lung/tracheobronchial tree | 90     | 84.11       |
| Mediastinum                | 16     | 14.95       |
| Bony structure             | 1      | 0.93        |
| Esophagus                  | 0      | 0.00        |
| Total                      | 107    | 100.00      |

**Table 2.** Number of the patients according to type of contrast materials

| Group      | Number | Percent (%) |
|------------|--------|-------------|
| CMC+Ba     | 29     | 27.10       |
| Starch+Ba  | 41     | 38.32       |
| Commercial | 37     | 34.58       |
| Total      | 107    | 100.00      |

**Table 3.** Number of slices in each grade and type of contrast in overall patients

| Grade | CMC+Ba          | Starch+Ba       | Commercial      | Total            | p-value |
|-------|-----------------|-----------------|-----------------|------------------|---------|
| 0     | 1,581 (46.07%)  | 1,855 (43.88%)  | 1,563 (35.78%)  | 4,999 (41.56%)   | <0.005  |
| 1     | 1,252 (36.48%)  | 1,539 (36.41%)  | 1,602 (36.68%)  | 4,393 (36.53%)   |         |
| 2     | 599 (17.45%)    | 833 (19.71%)    | 1,203 (27.54%)  | 2,635 (21.91%)   |         |
| Total | 3,432 (100.00%) | 4,227 (100.00%) | 4,368 (100.00%) | 12,027 (100.00%) |         |

**Table 4.** Number of the slices in the cervical segment

| Grade | CMC+Ba        | Starch+Ba     | Commercial    | Total           | p-value |
|-------|---------------|---------------|---------------|-----------------|---------|
| 0     | 367 (56.29%)  | 456 (54.61%)  | 324 (44.51%)  | 1,147 (51.78%)  | <0.005  |
| 1     | 204 (31.29%)  | 234 (28.02%)  | 191 (26.24%)  | 629 (28.40%)    |         |
| 2     | 81 (12.42%)   | 145 (17.37%)  | 213 (29.26%)  | 439 (19.82%)    |         |
| Total | 652 (100.00%) | 835 (100.00%) | 728 (100.00%) | 2,215 (100.00%) |         |

**Table 5.** Number of the slices in the thoracic segment

| Grade | CMC+Ba          | Starch+Ba       | Commercial      | Total           | p-value |
|-------|-----------------|-----------------|-----------------|-----------------|---------|
| 0     | 1,027 (42.53%)  | 1,163 (39.57%)  | 976 (30.70%)    | 3,166 (37.10%)  | <0.005  |
| 1     | 909 (37.64%)    | 1,152 (39.20%)  | 1,249 (39.29%)  | 3,310 (38.79%)  |         |
| 2     | 479 (19.83%)    | 624 (21.23%)    | 954 (30.01%)    | 2,057 (24.11%)  |         |
| Total | 2,415 (100.00%) | 2,939 (100.00%) | 3,179 (100.00%) | 8,533 (100.00%) |         |

**Table 6.** Number of the slices in the intra-abdominal segment

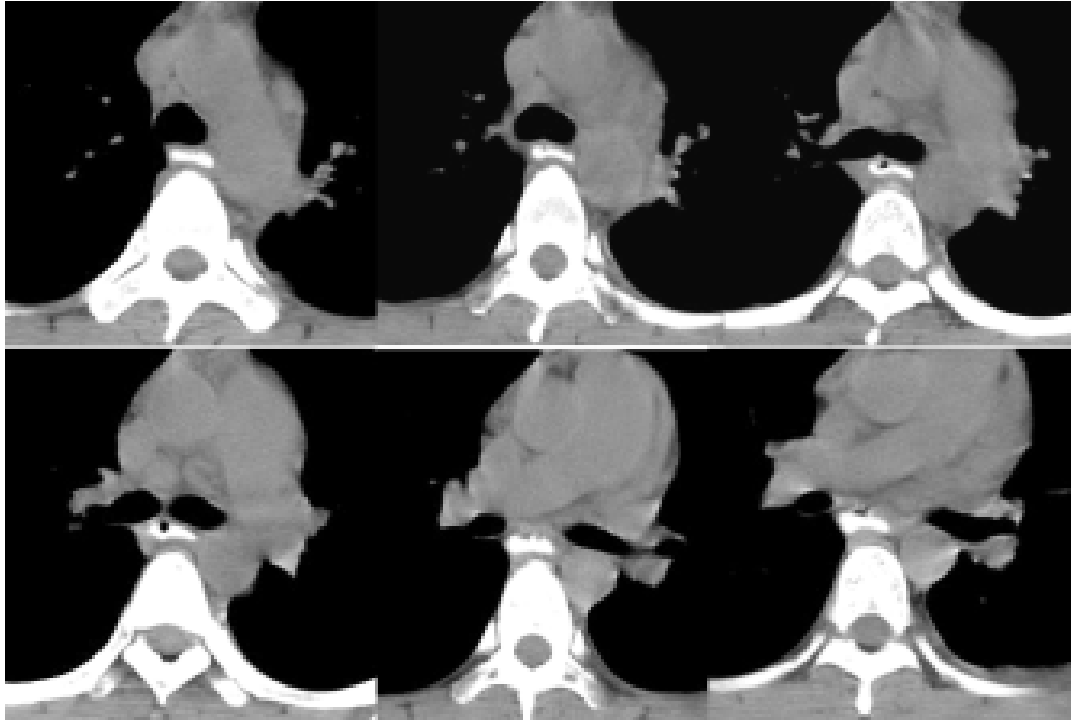
| Grade | CMC+Ba        | Starch+Ba     | Commercial    | Total           | p-value |
|-------|---------------|---------------|---------------|-----------------|---------|
| 0     | 187 (51.23%)  | 236 (52.10%)  | 263 (57.05%)  | 686 (53.64%)    | 0.026   |
| 1     | 139 (38.08%)  | 153 (33.77%)  | 162 (35.14%)  | 454 (35.50%)    |         |
| 2     | 39 (10.68%)   | 64 (14.13%)   | 36 (7.81%)    | 139 (10.87%)    |         |
| Total | 365 (100.00%) | 453 (100.00%) | 461 (100.00%) | 1,279 (100.00%) |         |

**Table 7.** Numbers of the patients' complaints regarding the taste of the contrast materials

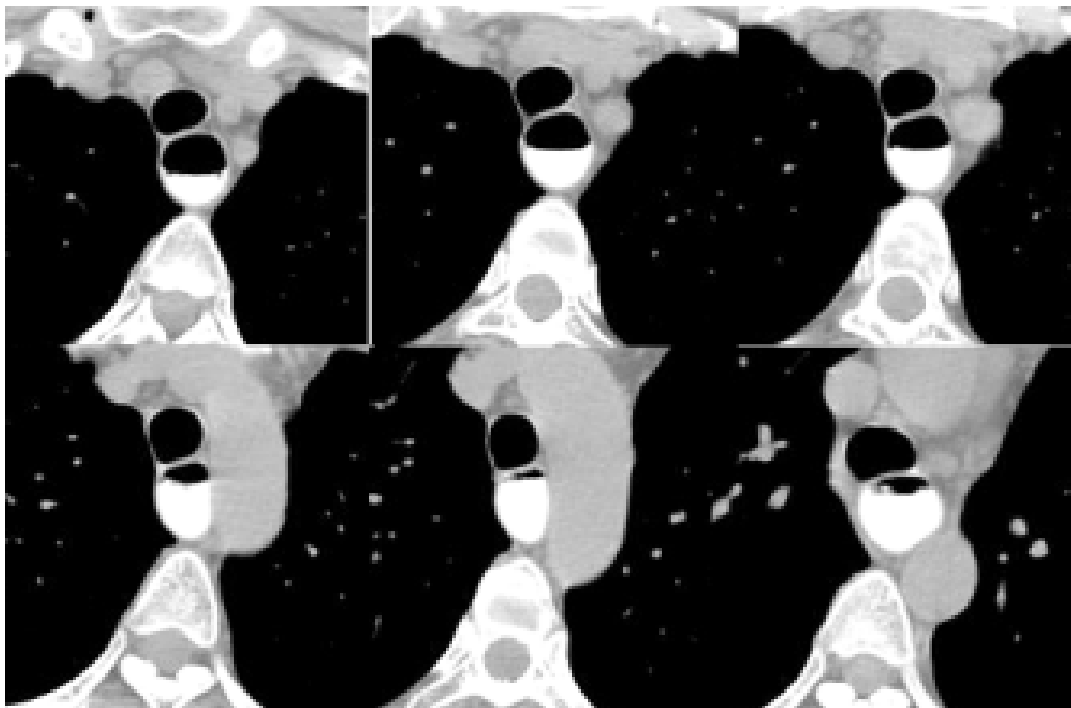
| Taste of contrast   | CMC+Ba | Starch+Ba | Commercial | Total |
|---------------------|--------|-----------|------------|-------|
| Impossible to drink | 0      | 1         | 0          | 1     |
| Awful taste         | 2      | 3         | 2          | 7     |
| Moderate taste      | 11     | 8         | 14         | 33    |
| Good taste          | 11     | 20        | 15         | 46    |
| Excellent taste     | 5      | 9         | 6          | 20    |
| Total               | 29     | 41        | 37         | 107   |

**Table 8.** Number of the patients who developed difficulty in swallowing

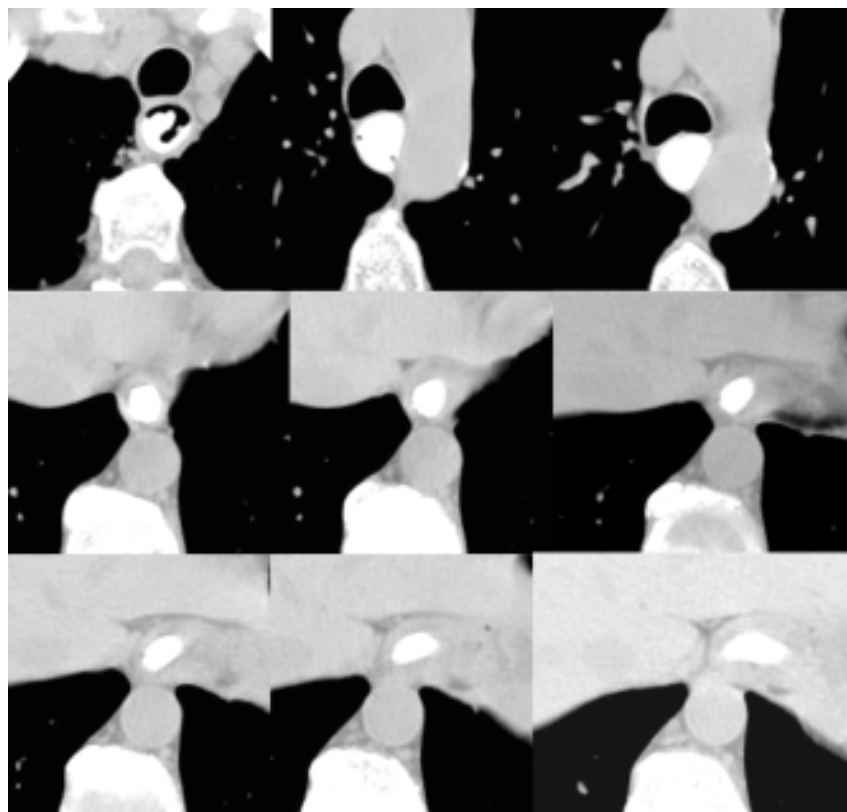
| Difficulty in swallowing | CMC+Ba | Starch+Ba | Commercial | Total |
|--------------------------|--------|-----------|------------|-------|
| No                       | 21     | 33        | 16         | 70    |
| Mild                     | 6      | 5         | 17         | 28    |
| Moderate                 | 2      | 3         | 4          | 9     |
| Severe                   | 0      | 0         | 0          | 0     |
| Total                    | 29     | 41        | 37         | 107   |



**Fig. 1** An example of grade 1 opacification of the esophageal lumen



**Fig. 2** An example of grade 2 opacification of the esophageal lumen seen with contrast-air level



**Fig. 3** Another example of grade 2 opacification of the esophageal lumen with contrast only

been rapidly developed over the last decade. In daily clinical practice, identification of the esophageal lumen, a prerequisite for the precise CT evaluation of the esophageal disease, is usually markedly difficult in the absence of air or contrast material. Water-soluble contrast materials are sometimes used in some institutions. However, they are not satisfactory for distension and coating. So far, there are few oral contrast materials developed for this purpose<sup>(9-11)</sup>. In spite of its extensive clinical use, opacification rate especially for the distal segment of the esophagus is still far from satisfactory<sup>(10)</sup>. In the present study, routine spiral CT scans of the chest, which used either one of the two developed oral contrast materials or a commercial barium paste, were collected, and analyzed.

Streak artifacts from these contrast materials were not present in any of the examinations, indicating proper concentration of barium sulfate in two developed oral contrast material and amount of a commercial barium paste.

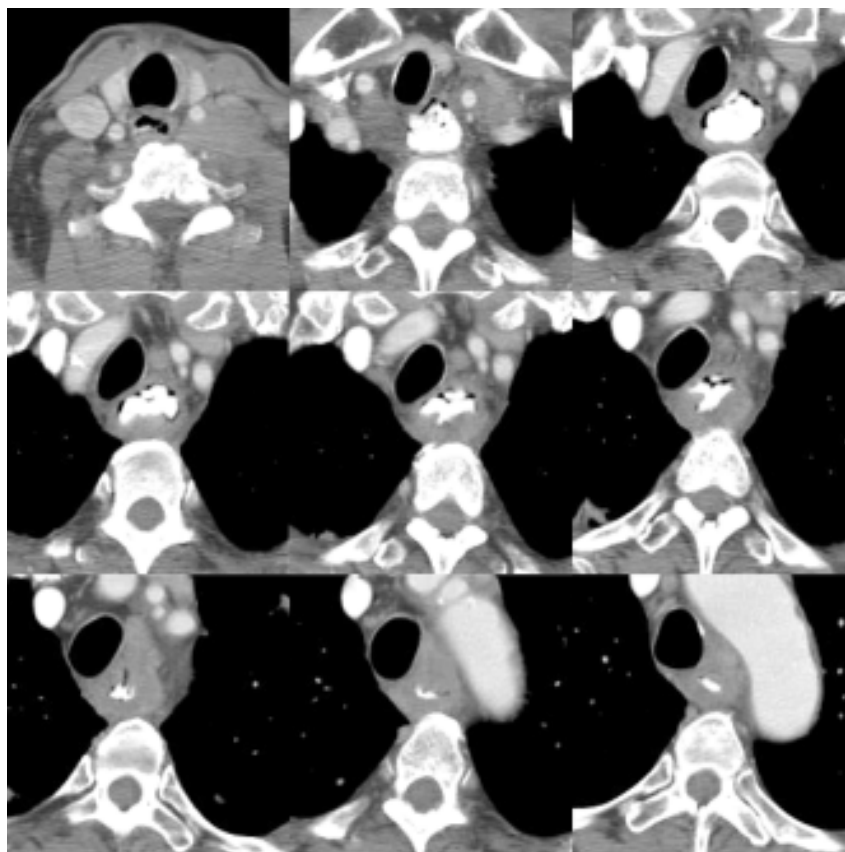
Grade 1 and 2 opacification of the commercial barium paste in all segments was 36.68% and 27.54%,

respectively, compared to 19.9% and 67.4% as described in the prior study by Conces et al<sup>(9)</sup>. One explanation is due to differences in administration time during the examination. The prior study kept the time between administration of the esophageal contrast material and the beginning of the scan to a minimum. These two factors prolonged the time that the contrast material was present within the esophagus, resulting in improvement in opacification. Another reason may be due to differences in the amount of the contrast material between 30 ml of the present study and 50 ml of the previous study<sup>(9)</sup>.

The result of CMC containing 2% barium sulfate is also less opacifying esophageal lumen as compared to the study of Noda et al<sup>(11)</sup>. This is probably due to differences in sample size of two series as well as in concentration of the carboxy-methyl cellulose sodium, between 1.5% in the present study and 3.6% in the previous study.

Although the overall degree of contrast opacification of the aforementioned contrasts was less than in the prior studies, the current study has the





**Fig. 4** Abnormal esophageal wall thickening detected in this study

advantage of a newly developed oral contrast material for CT to evaluate esophageal lumen. A 5.5% (wt/vol) starch containing 2% (wt/vol) barium sulfate was performed safely in the same method as commercial barium paste. It has been used for bowel opacification in the CT scan of the abdomen in the study of Lonnemark et al<sup>(12)</sup>. Neither study used it for evaluating the opacification of the esophagus. Percentage of opacification of this contrast material was 36.41% and 19.41% in grade 1 and grade 2, respectively.

Comparing luminal opacification between segments of the esophagus, all of the contrast materials showed the best results in the thoracic segment. The cervical and intra-abdominal segments gave less satisfaction and there was no significant difference between the two. The opacification of the intra-abdominal segment, especially the esophagogastric junction, was the same as the result of the prior study<sup>(9,10)</sup>. This is due to high resting pressure at the esophagogastric junction, squeezing the contrast material out of this portion of the esophagus.

Luminal irregularity, a characteristic usually seen with conventional barium studies, was detected in one case with primary non-small cell lung cancer with multiple pulmonary nodules and clinical progressive dysphagia. Prior CT scan showed multiple lung nodules and suspected soft tissue density at the area of upper esophagus, which was questionable for lymph node enlargement or esophageal lesion. While barium swallow study showed neither mucosal destruction nor obstruction of the esophagus, the presented recent CT scan with esophageal contrast revealed esophageal wall thickening. This newly diagnosed mean is a sensitive method to evaluate extension of involvement with second primary esophageal cancer.

The taste of all contrast materials was fair, except for eight patients who made the complaint of impossible to swallow and awful taste, particularly the starch containing barium sulfate. Thirty-five percent of the overall patients developed mild to moderate difficulty in swallowing. However, no medication or inter-



vention was required. In addition, none of the patients developed chest discomfort during the studies. The consistency of the preparation is important for the patient's ability to swallow the contrast.

The two developed oral contrast materials, particularly potato starch with an ordinary food additive, are available and cheap. The cost of two developed oral contrast materials per person is not more than \$1 U.S. Dollar, whereas commercial barium paste is about US \$25.

Future study should include esophageal opacification using more amounts of the contrast materials or repeated dose of the contrast materials in the post-intravenous contrast administration.

Future study for esophageal carcinoma CT should also include luminal opacification of the esophagus, which may demonstrate much difference from the normal esophagus, including position and extension of the cancer, loss of peristalsis in the cancerous segment and dilatation of the proximal segments as well as destruction of normal mucosa.

### Conclusion

The results in opacification of the esophageal lumen obtained with commercial barium paste and CMC containing 2% barium sulfate were lower than those obtained in prior studies. However, there is still a need for oral contrast material for opacifying esophageal lumen which exists for CT with better distribution properties than water soluble contrast material that are available today. Furthermore, cheap and local starch containing 2% barium sulfate is a developed oral contrast material for CT in evaluating the esophagus. It is a new method of esophageal CT that is safe and easy to perform and well tolerated by most of the patients. In addition, all oral contrast materials in the present study showed no streak artifact with acceptable taste of only mild to moderate difficulty in swallowing during the procedure. Furthermore, it is a cost-effective solution. Therefore, using those in a selected case in CT of the neck, chest, and upper abdomen for clarifying problem areas is encouraged. The aforesaid mention is most valuable in the thoracic segment of the esophagus and least in the intra-abdominal segment. Future clinical trials in optimal opacification and distribution properties should be done.

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## สารทึบรังสีชนิดกินในการตรวจเอกซเรย์คอมพิวเตอร์เพื่อดูหลอดอาหาร

กมลมาศ เลหาวิริยะกมล, จิรพร เหล่าธรรมทัศน์, ยุพา จรรย์วงศ์กุล

**ภูมิหลัง:** ปัจจุบันมีวิธีการวินิจฉัยโรคของหลอดอาหารหลายวิธี การตรวจเอกซเรย์คอมพิวเตอร์ (CT) เป็นวิธีหนึ่งที่เหมาะสมหลาย ให้ข้อมูลทั้งที่เกี่ยวกับหลอดอาหารและพยาธิสภาพของอวัยวะใกล้เคียงที่เกี่ยวข้อง แต่ในปัจจุบันยังไม่มีสารทึบรังสีที่เหมาะสมในการเคลือบหลอดอาหาร เพื่อดูตำแหน่งและความหนาซึ่งมีความสำคัญในการวินิจฉัยพยาธิสภาพเป็นอย่างมาก

**วัตถุประสงค์:** การศึกษานี้เป็นการเก็บข้อมูลไปข้างหน้าเพื่อดูผลของการเคลือบหลอดอาหารจากการตรวจเอกซเรย์คอมพิวเตอร์ ประเมินผลข้างเคียงระยะสั้น รวมถึงรสชาติของสารทึบรังสี

**วัสดุและวิธีการ:** สารทึบรังสีที่ใช้ในการศึกษาประกอบด้วย 1.5%(wt/vol) carboxy-methyl cellulose sodium (CMC) paste ผสมกับ แบเรียม ซัลเฟต 2% (น้ำหนัก/ปริมาตร), 5.5% แป้งมันสำปะหลัง ผสมกับ แบเรียม ซัลเฟต 2% (น้ำหนัก/ปริมาตร) และ แป้งแบเรียม 3% (น้ำหนัก/น้ำหนัก) ที่มีจำหน่ายสำหรับการตรวจเอกซเรย์คอมพิวเตอร์ ผู้ป่วยจะดื่มสารทึบรังสี 1 ชนิดโดยใช้วิธีการสุ่ม จากนั้นทำการตรวจเอกซเรย์คอมพิวเตอร์บริเวณช่องอกตามปกติ รังสีแพทย์จะประเมินประสิทธิภาพของการเคลือบหลอดอาหารโดยไม่ทราบว่าผู้ป่วยแต่ละรายได้รับสารทึบรังสีชนิดใด

**ผลการศึกษา:** ผู้ป่วยทั้งสิ้น 107 ราย พบว่าผลการเคลือบหลอดอาหารระดับ 1 (มีสารทึบรังสี แต่หลอดอาหารไม่โป่งพอง) และระดับ 2 (มีสารทึบรังสี แต่หลอดอาหารโป่งพอง) ในการเคลือบสำหรับส่วนผสมของ CMC เท่ากับ 36.48% และ 17.45% ในขณะที่ส่วนผสมของแป้งมันสำปะหลัง เท่ากับ 36.41% และ 19.71% ส่วนผลการเคลือบของแป้งแบเรียมที่มีจำหน่าย เท่ากับ 36.68% และ 27.54% ตามลำดับ ในส่วนของรสชาติจากผลการสอบถามได้ผลดี มีผู้ป่วยคิดเป็น 35% รู้สึกมีความยากลำบากในการกลืนเล็กน้อยถึงปานกลาง โดยที่ไม่จำเป็นต้องได้รับการดูแลหรือแก้ไขใด ๆ โดยเฉพาะ

**สรุป:** สารทึบรังสีที่ใช้ในการศึกษาทั้ง 3 ชนิดมีผลการเคลือบหลอดอาหารจากการตรวจเอกซเรย์คอมพิวเตอร์ได้น้อยกว่าผลการศึกษาที่ผ่านมา อย่างไรก็ตาม รสชาติของสารทึบรังสีซึ่งสามารถยอมรับได้ และมีความยากลำบากในการกลืนเล็กน้อย รวมถึงราคาไม่แพงและเป็นสารที่หาได้ทั่วไป ทำให้สารทึบรังสีที่ได้รับการพัฒนาขึ้น สมควรนำมาพิจารณา ใช้เฉพาะในกรณีที่สงสัยพยาธิสภาพในหลอดอาหารหรืออวัยวะใกล้เคียง ในการตรวจเอกซเรย์คอมพิวเตอร์ส่วนคอ หน้าอก หรือ ช่องท้องส่วนบน แทนการไม่ใช้สารทึบรังสีเลย หรือ การใช้สารทึบรังสีที่ไม่สามารถทำให้หลอดอาหารโป่งพอง หรือ ไม่สามารถเคลือบหลอดอาหารได้

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