# Comparison of Pasteurized Whole Milk, UHT Whole Milk, Water, and Diluted Iodine Contrast as Computed Tomographic Enteric Contrasts

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***Objective:*** *To compare four computed tomographic (CT) enteric contrasts (pasteurized whole milk, UHT whole milk, water, and diluted iodine contrast) in various aspects, including gastrointestinal (GI) distension, mural visualization, GI landmark distinction, taste, patients' satisfaction, adverse effects, and prices.*

***Material and Method:*** *Sixty patients scheduled for whole abdominal CT at the present institution were randomized to receive 1,000 ml of pasteurized whole milk (n = 15), UHT whole milk (n = 15), water (n = 15) and diluted iodine contrast (n = 15) as CT enteric contrasts. Two radiologists separately assessed the GI distension (using a 4-point scale: poor, partial, good, and full), mural visualization (using a 3-point scale: poor, partial, and good), GI landmark distinction at esophagogastric (EG) junction, ampulla of Vater, and pancreatic head-duodenal loop (using a 3-point scale: poor, partial, and good). The participants graded the taste of received enteric contrasts and their satisfaction using a 4-point scale (unacceptable, unpleasant, acceptable, and pleasant). Adverse effects were evaluated by GI associated symptoms (nausea, vomiting, abdominal cramping/discomfort, and diarrhea).*

***Results:*** *Pasteurized whole milk was superior to other agents in GI distension and tended to be better than other agents in mural visualization and GI landmark distinction. No difference in taste and patients' satisfaction was noted between pasteurized whole milk and other agents. Gallbladder collapse was inevitable in participants with pasteurized and UHT whole milk consumption, due to 4% fat content in whole milk. GI adverse effects were more common in whole milk group than other agents. The prices of pasteurized whole milk, UHT whole milk, water, and diluted iodine contrast were about 42, 40, 14, and 36 Baht, respectively.*

***Conclusion:*** *Pasteurized whole milk is an attractive oral contrast agent, providing good GI distension, mural visualization, and GI landmark discrimination. Apart from gallbladder collapse, increase of GI adverse symptoms was another major drawback of whole milk when used as CT oral contrast, especially in Thai people.*

***Keywords:*** *Pasteurized milk, UHT milk, Whole milk, Iodine contrast, CT, computed tomography*

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High-attenuated enteric contrast agents, either diluted iodine solution or barium suspension, have been traditionally used for abdominal computed tomographic (CT) studies, assisting in the discrimination of bowel loops from intraabdominal lymph nodes, masses, collection, and abscesses. However, many drawbacks have been reported, such as streak artifacts from highly-concentrated contrast accumulated at esophagogastric (EG) junction, pseudotumor formation from inconsistent mixing with gastric content[1-3], and unpleasant taste. High-attenuated oral contrasts also impede the interpretation of ectopic gallstones, pedunculated fibroids and are not suitable for special CT studies with reconstruction processes, i.e. maximum intensity projection (MIP) technique for CT angiography (CTA) or CT urography (CTU). In spite of these problems, another major drawback is the obscuration of mural visualization from the high-attenuated luminal content. The subtle enhancing abnormality of bowel wall or organs located closely to the bowel lumen is difficult to appreciate.

Many low-attenuated enteric contrasts have been proposed to overcome the problem of obscured mural visualization. However, they also provide some limitations. Air has been used for special CT technique

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such as CT gastrography[4,5], but is not suitable for routine abdominal CT, since enteric distension with air is more uncomfortable than with other fluid contrasts. Furthermore, air may necessitate a wide window display during viewing, which may not be appropriate for soft tissue contrast of abdominal organ visualization. Raptopoulos et al[1] introduced 12.5% corn oil emulsion as a CT oral contrast agent. However, such an agent was not commercially available and required in-house preparation. The high fat content was also unpleasant for ingestion and not good for health. In their study, 10-20 mg of metoclopramide hydrochloride was orally added in all patients to prevent the delayed gastric emptying time caused by high fat component. Many centers have adopted water as their routine low-attenuated oral contrast[6-10], since water is cheap, widely available and helpful in promoting bowel wall visualization. However, the few drawbacks of water are well recognized. Compared to high-attenuated contrast, water is more rapidly absorbed by enteric mucosa and cause suboptimal distension of distal small bowels. Glucagon administration may promote bowel distension, but this will increase the expense and complicate the preparation process. Glucagon administration is also risky in diabetic patients. Moreover, enteric fistula or small intraabdominal cystic lesions (e.g. abscess, fluid collection, and pseudocyst) may be difficult to identify in case of water ingestion.

To combine the benefit of gastrointestinal (GI) distension and mural visualization, pasteurized whole milk has been proposed as a new oral contrast agent[11,12]. It promotes mural visualization since it is a low-attenuated oral contrast. In the same time, it also promotes GI distension because of high fat content. Thompson et al[11] reported the superiority of whole (4%) milk to 2% milk in GI distension, mural visualization, and pancreas-duodenum discrimination. They reported a low incidence of adverse effects (only one patient had nausea and vomiting during intravenous injection of contrast media).

At Department of Radiology, Faculty of Medicine Siriraj Hospital, there are more than 10,000 abdominal CT studies performed each year. The authors have routinely used either water or diluted iodine contrast as CT oral contrasts. The authors were interested in using whole milk as CT enteric contrast. Anyhow, most Thai people are not familiar with milk consumption compared to Caucasians. Nausea, vomiting, abdominal cramping/discomfort, and diarrhea are common GI symptoms seen in many Thai people after milk consumption. The authors hypothesize that gallbladder collapse is another downside after large amount of milk consumption. These two aspects have not been studied thoroughly before. Pasteurized whole milk needs to be kept in the refrigerator and has only a short-lasting time before spoilage. In contrast, ultra-high-temperature processing (UHT) milk can be stored for a longer period with no need to be kept in the refrigerator, and would be more convenient for daily use as CT enteric contrast. Therefore, the authors selected both pasteurized whole milk and UHT whole milk to be analyzed with the routinely used enteric contrasts (water and diluted iodine contrast) in many aspects, including GI distension (as well as gallbladder), mural visualization, GI landmark distinction, taste, patients' satisfaction, adverse effects, and prices to identify the most suitable CT oral contrast agent for Thai people.

## Material and Method

### *Study design and sample size calculation*

The present study was a prospective randomized controlled trial performed at a 3,000-bed university hospital in central Thailand. The present study was approved by the hospital institutional review board. Written informed consents were obtained from all participants. The sample size was calculated based on GI distension of whole milk, water and diluted iodine contrast from the pilot project using one-way analysis of variance and the nQuery Advisor program. The variance of means and the common standard deviation calculated from the pilot project were 0.074 and 0.510, respectively. A sample size of 15 patients would be required in each group (60 patients for four analyzed enteric contrasts) to demonstrate the superiority of milk in GI distension at the two-sided significant level of 5% with a power of 80%.

### *Participants and CT techniques*

Between August and November 2010, sixty cooperated adult patients scheduled for contrast-enhanced whole abdominal CT at Siriraj Hospital were recruited in the present study. Patients with a history of milk allergy or lactose intolerance were excluded from the study population, as well as the patients with impaired renal function. Patients scheduled for special CT technique using MIP reconstruction, i.e. CT angiography or CT urography, were also excluded from the study program. After signing the informed consent, the participants were equally randomized into four groups according to a computer-generated list using blocked randomizations (varied block of

4, 8, 12 and 16) and sealed envelope technique. Each group received one of four analyzed CT oral contrasts: Group 1 - pasteurized whole milk (Meiji, Thai Meiji Food Co., Ltd., Bangkok, Thailand; or Dutch Mill, Dutch Mill Group, Nakornpathom, Thailand); Group 2 - UHT whole milk (Nongpho, Nongpho Dairy Co., Ltd., Ratchaburi, Thailand); Group 3 - water; and Group 4 - diluted iodine contrast (one of the following 2% nonionic iodine contrasts in diluted syrup: Optiray 300, Tyco Healthcare, Canada; Iomeron 300, Bracco Imaging SpA. Italy; Ultravist 370, Bayer Korea, Korea; and Hexabrix 320, Guerbet, France). The total amount of oral contrast ingestion was 1,000 ml, divided into four glasses, 250 ml per glass. The first glass of oral contrast was provided to each participant about 45 minutes prior to the CT study. Then, each glass of oral contrast was subsequently provided every 15 minutes. The last glass of received contrast was administered by each participant just before entering the CT room.

All participants received diluted iodine contrast enema on the CT table as their tolerance in order to promote the visualization and the distension of colon. Each participant's CT whole abdomen was performed by one of two 64-slice CT scanners (LightSpeed VCT, GE Healthcare, United States; and SOMATOM Definition Dual Source, Siemens, Germany) before and after a bolus injection of 100 ml of nonionic iodinated intravenous contrast agent by a power injector at a rate of 2 ml/second. Imaging data was stored in Picture Archiving and Communication System (PACS) and was subsequently interpreted by radiologists who were on duty that day.

### *Data record*

The participants' studies were retrospectively reviewed by two gastrointestinal radiologists (PA and SP, with 14 and 8 years of experience with CT whole abdomen), independently. Both radiologists were blinded to the type of received enteric contrasts and the data in the case record form. They separately graded the GI distension at stomach, duodenum, jejunum, ileum and gallbladder of each participant using a 4-point ordinal scale 1-4 (1 = poor distension, 2 = partial distension, 3 = good distension, and 4 = full distension). Mural visualization at stomach, duodenum, jejunum, and ileum of each participant were also graded by using a 3-point ordinal scale 1-3 (1 = poor visualization, 2 = partial visualization, and 3 = good visualization). Then, they separately identified three GI landmarks: EG junction, ampulla of Vater, and pancreatic head-duodenal loop. Subsequently, they graded the degree of distinction/visualization of these three landmarks of each participant using a 3-point ordinal scale 1-3 (1 = poor distinction, 2 = partial distinction, and 3 = good distinction).

Each participant was interviewed by phone within two days after the CT study by one of the investigators (TP). The recorded data was the sex, age, underlying disease, and the four associated symptoms (nausea, vomiting, abdominal cramping/discomfort, and diarrhea). Each associated symptom was graded by the participants using a three-point ordinal scale 0-2 (0 = no symptom, 1 = mild degree, and 2 = severe degree). Then, each participant was requested to grade the taste and overall satisfaction/attitude of received contrast agent using a 4-point ordinal scale (1 = unacceptable, 2 = unpleasant, 3 = acceptable, and 4 = pleasant).

### *Statistical analyses*

The scores of GI distension, mural visualization, and GI landmark distinction of each anatomic segment of each participant were the average scores received from both radiologists. To compare the differences in median score for GI distention, mural visualization, GI landmark distinction, taste and patients' satisfaction, a Kruskal-Wallis test and multiple comparisons (Conover-Inman method) were applied. All statistical data analyses were performed by using SPSS version 19.0 (SPSS Inc., Illinois, United States). A 2-sided p-value of less than or equal to 0.05 was considered as statistical significance.

## Results

### *Participants*

Sixty participants in the present study were 11 men, 49 women with the age range between 22 and 77 years (mean = 51.1 years, SD = 12.2). Subjects in the four groups designated above were comparable with regard to gender (female: 80.0% vs. 93.3% vs. 73.3% vs. 80.0% in group 1-4, respectively) and age (mean±SD: 49.8±11.6 vs. 49.1±12.7 vs. 52.8±11.7 vs. 52.7±13.5 in group 1-4, respectively).

Underlying diseases of the participants in the present study were uterine cervical cancer (n = 17), ovarian cancer (n = 13), colonic cancer (n = 10), lymphoma (n = 7), endometrial cancer (n = 3), bronchogenic cancer (n = 3), chronic dyspepsia (n = 2), prostate cancer (n = 1), GI stromal tumor (n = 1), neuroendocrine tumor (n = 1), malignant fibrous histiocytoma (n = 1), and unknown hepatic metastases (n = 1).

***GI distension***

The degree of GI distension of these four oral contrast agents was displayed in Table 1. For overall GI distension, pasteurized whole milk was superior to UHT whole milk, water and diluted iodine contrast (Fig. 1). As expected, water was inferior to other three agents, espcially at the ileal region due to early absorption of water from small bowel mucosa. To focus on each location, both pasteurized whole milk and UHT whole milk were significantly superior to water and diluted iodine contrast for gastric distension. Unfortunately, whole milk had high fat content, which delayed the gastric emptying time. A large amount of milk was left in the stomach, and not propagated to small bowel segments. As expected, fat content in pasteurized whole milk and UHT whole milk caused

**Table 1.** Comparison of the GI distension score of these 4 CT enteric contrasts, displayed as median score (minimum score, maximum score) (n = 60)

| GI distension score | Pasteurized whole milk (1) (n = 15) | UHT whole milk (2) (n = 15) | Water (3) (n = 15) | Diluted iodine contrast (4) (n = 15) | p-value | Remarks |
|---|---|---|---|---|---|---|
| Stomach | 4.0 (4.0, 4.0) | 4.0 (3.5, 4.0) | 2.5 (1.0, 4.0) | 3.0 (1.5, 3.5) | <0.001 | 1-3, 1-4, 2-3, 2-4 |
| Duodenum | 3.0 (1.5, 3.5) | 2.0 (1.0, 3.5) | 2.0 (1.0, 3.5) | 2.0 (1.0, 3.0) | 0.029 | 1-2, 1-3, 1-4 |
| Jejunum | 2.5 (2.0, 3.5) | 2.0 (1.5, 3.0) | 2.0 (1.0, 3.0) | 3.0 (2.0, 4.0) | 0.001 | 4-2, 4-3 |
| Ileum | 3.0 (2.0, 3.5) | 3.0 (2.0, 3.5) | 2.5 (1.0, 3.0) | 3.0 (2.5, 3.5) | 0.004 | 1-3, 2-3, 4-3 |
| Average score | 3.0 (2.6, 3.4) | 2.8 (2.4, 3.3) | 2.5 (1.1, 3.0) | 2.8 (2.0, 3.4) | <0.001 | 1-2, 1-3, 1-4, 2-3, 4-3 |

Remarks: Identify the pairs of which are significantly different (p-value ≤0.05) in the GI distension score. The former number represents an enteric contrast that is significantly superior to the latter number.

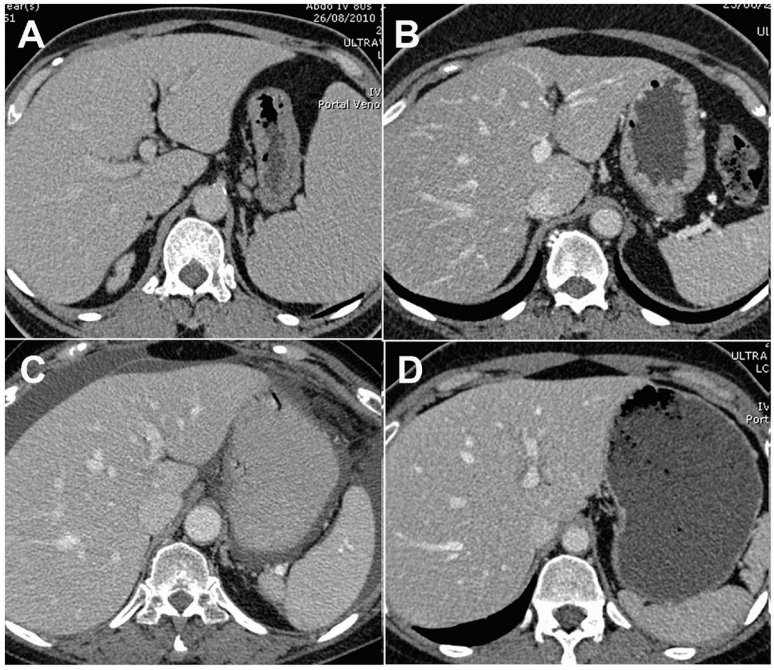


**Fig. 1** Axial post-enhanced CT abdomen of 4 participants show different degrees of gastric distension.
A) Poor gastric distention (Group 3: water)
B) Partial gastric distention (Group 3: water)
C) Good gastric distention (Group 4: diluted iodine contrast)
D) Full gastric distention (Group 1: pasteurized whole milk)
Notice pasteurized whole milk (1D) is superior in GI distension to other agents while water is inferior to other agents (1A-B).

significant gallbladder collapse when compared to water and diluted iodine contrast (Table 2, Fig. 2).

***Mural visualization***

The degree of mural visualization of these four oral contrast agents was displayed in Table 3. Overall, diluted iodine contrast was inferior to other agents in mural visualization (Fig. 3) as its high-density content obscured mural visualization. Both radiologists noticed that GI distension had an effect on mural visualization. Well distended bowel loops had higher mural visualization scores than the collapsed bowel loops (Fig. 4). Interestingly, pasteurized whole milk was superior to UHT whole milk in mural visualization.

***GI landmark distinction***

The degree of GI landmark distinction (EG junction, ampulla of Vater, and pancreatic head-duodenal loop) of these four oral contrast agents was displayed in Table 4. Overall, water and diluted iodine contrast was inferior to pasteurized whole milk and

**Table 2.** Comparison of the gallbladder distension score of these 4 CT enteric contrasts, displayed as median score (minimum score, maximum score)

| Distension score | Pasteurized whole milk (1) | UHT whole milk (2) | Water (3) | Diluted iodine contrast (4) | p-value | Remarks |
|---|---|---|---|---|---|---|
| GB | 2.0 (1.5, 3.0) | 2.0 (1.5, 4.0) | 3.0 (1.5, 4.0) | 3.0 (3.0, 4.0) | <0.001 | 3-1, 3-2, 4-1, 4-2 |

Remarks: Identify the pairs of which are significantly different (p-value ≤0.05) in the gallbladder distension score. The former number represents an enteric contrast that is significantly superior to the latter number.

**Table 3.** Comparison of the mural visualization score of these 4 CT enteric contrasts, displayed as median score (minimum score, maximum score)

| Mural visualization | Pasteurized whole milk (1) | UHT whole milk (2) | Water (3) | Diluted iodine contrast (4) | p-value | Remarks |
|---|---|---|---|---|---|---|
| Stomach | 3.0 (3.0, 3.0) | 3.0 (3.0, 3.0) | 3.0 (1.5, 3.0) | 2.5 (2.0, 3.0) | <0.001 | 1-4, 2-4, 3-4 |
| Duodenum | 3.0 (2.0, 3.0) | 2.5 (1.5, 3.0) | 3.0 (1.5, 3.0) | 2.0 (1.0, 3.0) | 0.002 | 1-4, 2-4, 3-4 |
| Jejunum | 2.5 (2.0, 3.0) | 2.5 (1.0. 3.0) | 2.5 (1.0, 3.0) | 2.5 (2.0, 3.0) | 0.260 | |
| Ileum | 3.0 (2.5, 3.0) | 3.0 (1.5, 3.0) | 3.0 (1.5, 3.0) | 3.0 (2.5, 3.0) | 0.092 | |
| Average score | 2.9 (2.5, 3.0) | 2.8 (2.1, 3.0) | 2.8 (1.5, 3.0) | 2.4 (2.1, 2.9) | <0.001 | 1-2, 1-4, 2-4, 3-4 |

Remarks: Identify the pairs of which are significantly different (p-value ≤0.05) in the mural visualization score. The former number represents an enteric contrast that is significantly superior to the latter number.

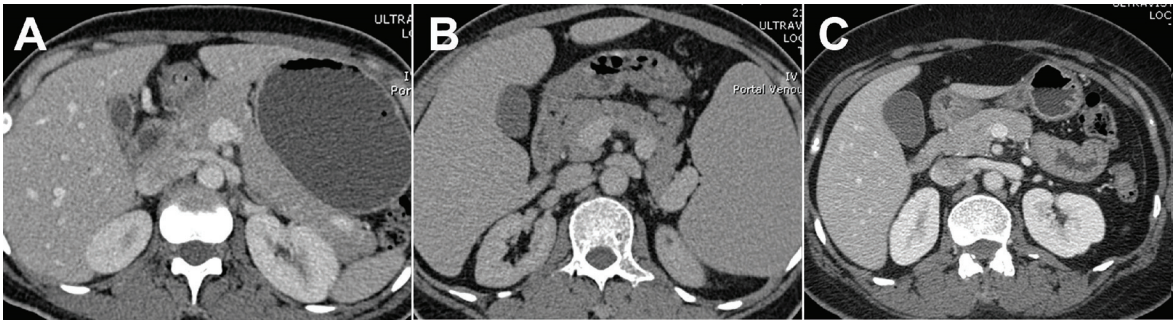


**Fig. 2** Axial post-enhanced CT abdomen of 3 participants show different degrees of gallbladder distension.
A) Partial gallbladder distention (Group 1: pasteurized whole milk)
B) Good gallbladder distension (Group 3: water)
C) Full gallbladder distention (Group 3: water)
Notice high fat content in pasteurized whole milk (2A) causes significant collapse of gallbladder compared to water (2B-C).

UHT whole milk. These could be explained in part due to diluted iodine contrast caused high-attenuated luminal content that could obscure the visualization of GI landmarks (Fig. 5, 6). Although water was a low-attenuated contrast as was whole milk, it was inferior to whole milk in GI distension. When GI lumen was not fully distended, the GI landmarks could not be well appreciated.

***Taste and patients' satisfaction***

The taste and overall patients' satisfaction with these four oral contrast agents graded by the

**Table 4.** Comparison of the GI landmark distinction score of these 4 CT enteric contrasts, displayed as median score (minimum score, maximum score)

| GI landmark distinction | Pasteurized whole milk (1) | UHT whole milk (2) | Water (3) | Diluted iodine contrast (4) | p-value | Remarks |
|---|---|---|---|---|---|---|
| EG junction | 3.0 (2.5, 3.0) | 3.0 (2.5, 3.0) | 2.5 (1.5, 3.0) | 2.5 (2.0, 3.0) | <0.001 | 1-3, 1-4, 2-3, 2-4 |
| Ampulla of Vater | 2.5 (1.0, 3.0) | 2.0 (1.0, 3.0) | 2.5 (1.0, 3.0) | 1.5 (1.0, 2.5) | 0.211 | |
| Pancreatic head-duodenum | 3.0 (2.0, 3.0) | 2.5 (1.0, 3.0) | 2.5 (1.5, 3.0) | 2.0 (1.5, 3.0) | 0.041 | 1-4 |
| Average score | 2.7 (2.0, 3.0) | 2.5 (1.7, 3.0) | 2.2 (1.5, 2.8) | 2.0 (1.7, 2.8) | 0.011 | 1-3, 1-4, 2-4 |

Remarks: Identify the pairs of which are significantly different (p-value ≤0.05) in the GI landmark distinction score. The former number represents an enteric contrast that is significantly superior to the latter number.

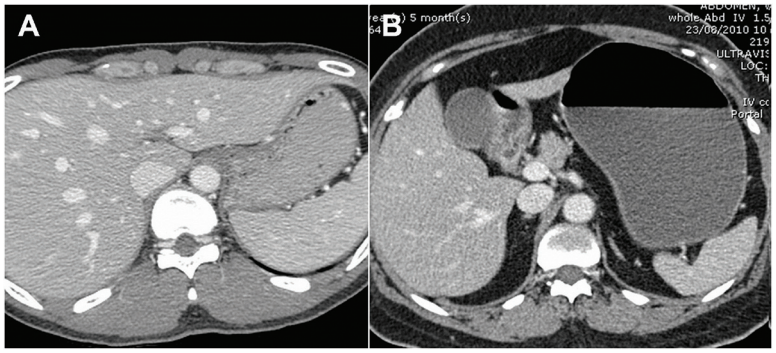


**Fig. 3** Axial post-enhanced CT abdomen of 2 participants show different degrees of gastric mural visualization.
A) Partial gastric mural visualization (Group 4: diluted iodine contrast)
B) Good gastric mural visualization (Group 2: UHT whole milk)
Notice high-attenuated contrast (3A) is inferior to low-attenuated contrast (3B) in mural visualization.

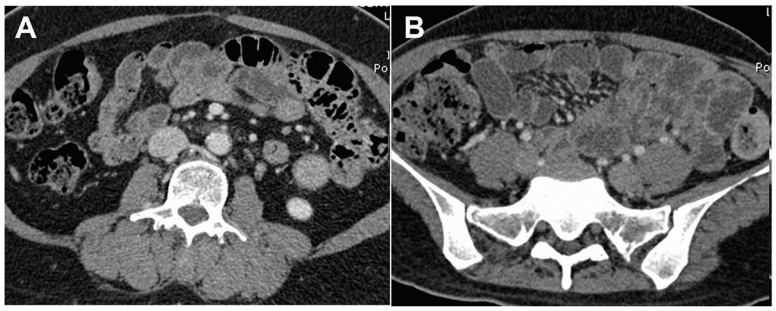


**Fig. 4** Axial post-enhanced CT abdomen of 2 participants show different degrees of small bowel mural visualization.
A) Partial small bowel mural visualization (Group 3: water)
B) Good small bowel mural visualization (Group 1: pasteurized whole milk)
Notice GI distension has an effect on mural visualization. Even both water (4A) and pasteurized whole milk (4B) are low-attenuated oral contrasts which should not obscure the mural visualization, but water is inferior to pasteurized whole milk in GI distension. Therefore, the degree of mural visualization in 4A is inferior to 4B.

participants were displayed in Table 5. Overall, UHT whole milk was inferior to water and diluted iodine contrast in either taste or patients' satisfaction; but not significantly different to pasteurized whole milk. No participants graded their overall satisfaction as unacceptable or unpleasant. However, two participants (13.3%) in the UHT whole milk group and one participant (6.7%) in the pasteurized whole milk group graded the taste as unpleasant (Table 6). However, when the authors defined the taste score into two levels: level 1: unsatisfied level (unacceptable to unpleasant) and level 2: satisfied level (acceptable to pleasant), all enteric contrasts show a high satisfied level for the taste score (86.7-100%).

***Adverse effects***

The adverse effects of these four oral contrast agents reported by the participants were displayed in

**Table 5.** Comparison of the taste and the patients' satisfaction score of these 4 CT enteric contrasts, displayed as median score (minimum score, maximum score)

| | Pasteurized whole milk (1) | UHT whole milk (2) | Water (3) | Diluted iodine contrast (4) | p-value | Remarks |
|---|---|---|---|---|---|---|
| Taste | 4.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | 4.0 (3.0, 4.0) | 4.0 (3.0, 4.0) | 0.001 | 3-2, 4-2 |
| Patient satisfaction | 4.0 (3.0, 4.0) | 4.0 (3.0, 4.0) | 4.0 (4.0, 4.0) | 4.0 (4.0, 4.0) | 0.001 | 3-2, 4-2 |

Remarks: Identify the pairs of which are significantly different (p-value ≤0.05) in the taste and patients' satisfaction score. The former number represents an enteric contrast that is significantly superior to the latter number.

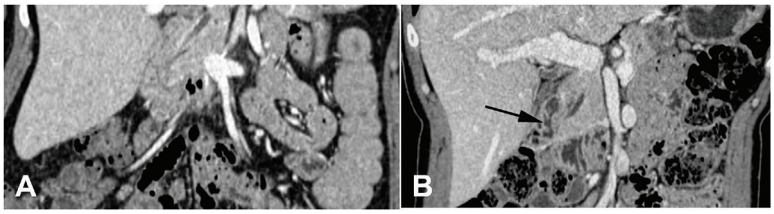


**Fig. 5** Coronal reformation of post-enhanced CT abdomen of 2 participants show different degrees of the distinction of ampulla of Vater.
A) Poor distinction of ampulla of Vater (Group 4: diluted iodine contrast)
B) Good distinction of ampulla of Vater (Group 1: pasteurized whole milk)
Notice high-attenuated contrast (5A) is inferior to low-attenuated contrast (5B) in the distinction of ampulla of Vater (arrow in 5B).

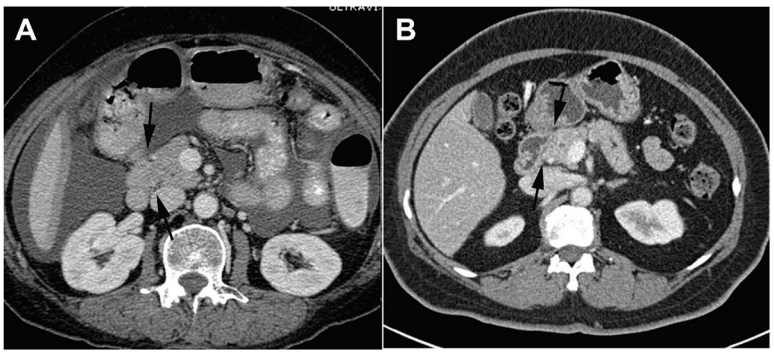


**Fig. 6** Axial post-enhanced CT abdomen of 2 participants show different degrees of pancreatic head-duodenal loop distinction (arrows in 6A and 6B).
A) Poor distinction of pancreatic head-duodenal loop (Group 4: diluted iodine contrast)
B) Good distinction of pancreatic head-duodenal loop (Group 1: pasteurized whole milk)
Notice high-attenuated contrast (6A) is inferior to low-attenuated contrast (6B) in pancreatic head-duodenal loop distinction.

**Table 6.** Comparison of the satisfied level of the taste score

| Satisfied level of the taste score | Pasteurized whole milk (1) | UHT whole milk (2) | Water (3) | Diluted iodine contrast (4) |
|---|---|---|---|---|
| Unacceptable-unpleasant | 1 (6.7%) | 2 (13.3%) | 0 | 0 |
| Acceptable-pleasant | 14 (93.3%) | 13 (86.7%) | 15 (100%) | 15 (100%) |

**Table 7.** The adverse effects of these 4 oral contrast agents reported by the participants

| Adverse effects | CT enteric contrasts | Symptom score | | |
|---|---|---|---|---|
| | | None (0) | Mild (1) | Severe (2) |
| Nausea | Pasteurized whole milk (1) | 14 | 1 | 0 |
| | UHT whole milk (2) | 13 | 2 | 0 |
| | Water (3) | 15 | 0 | 0 |
| | Diluted iodine contrast (4) | 15 | 0 | 0 |
| Vomiting | Pasteurized whole milk (1) | 15 | 0 | 0 |
| | UHT whole milk (2) | 13 | 2 | 0 |
| | Water (3) | 15 | 0 | 0 |
| | Diluted iodine contrast (4) | 15 | 0 | 0 |
| Abdominal cramping/discomfort | Pasteurized whole milk (1) | 14 | 1 | 0 |
| | UHT whole milk (2) | 13 | 2 | 0 |
| | Water (3) | 15 | 0 | 0 |
| | Diluted iodine contrast (4) | 15 | 0 | 0 |
| Diarrhea | Pasteurized whole milk (1) | 10 | 5 | 0 |
| | UHT whole milk (2) | 3 | 12 | 0 |
| | Water (3) | 15 | 0 | 0 |
| | Diluted iodine contrast (4) | 14 | 1 | 0 |

Table 7. Twelve patients in the UHT whole milk group reported a mild degree of immediate post-test adverse effects (8 patients had mild diarrhea, 2 patients had mild abdominal cramping/discomfort and mild diarrhea, and 2 patients had mild nausea, mild vomiting and mild diarrhea). Seven patients in the pasteurized whole milk group reported a mild degree of adverse effects (5 patients had mild diarrhea, 1 patients had mild nausea, 1 patient had mild abdominal cramping/discomfort). Only one patient in the diluted iodine contrast group had mild diarrhea. None of the patients in the water group reported any adverse effects.

***Prices***

The prices of these four oral contrast agents per 1 CT study were estimated as follows, pasteurized whole milk: 42 Baht, UHT whole milk: 40 Baht, water: 14 Baht, and diluted iodine contrast agent: 36 Baht.

**Discussion**

In the present study, the authors analyzed both pasteurized whole milk and UHT whole milk with the routinely used CT oral contrast agents (water and diluted iodine contrast) to identify the most suitable CT oral contrast for Thai patients. To the authors' surprise, UHT whole milk was significantly inferior to pasteurized whole milk in GI distension and mural visualization. Furthermore, more adverse effects were reported. Since only one trademark of UHT whole milk was used in the present study, the authors could not guarantee that the results of the present study would be confirmed for other trademarks of UHT whole milk because the difference in their compositions. For pasteurized whole milk, although it was overall superior to other agents in GI distension, only the stomach had full distension score. This scenario could be explained because whole milk had high fat content and caused delayed gastric emptying time. Therefore, the degree of small bowel distension was not as good as expected. The addition of metoclopramide (plasil®) may help decreasing the gastric emptying time and promoting small bowel distension. However, this would increase the expense and complicate the preparation process. Furthermore, whole milk caused collapse of the gallbladder and should not be used in patients who were suspected of gallbladder diseases. Both pasteurized whole milk and UHT whole milk had more GI adverse effects than the routinely used

oral contrasts. Although the patients with a history of milk allergy or lactose intolerance were excluded from the study population, the frequency of nausea, vomiting, abdominal cramping/discomfort, and diarrhea in the present study were still higher than in prior studies[11,12]. These were in part due to Thai patients were not familiar with milk consumption when compared to Caucasians. These inferior downsides of milk should be discussed thoroughly before applying milk as a routine CT oral contrast for Thai people.

VoLumen (E-Z-Em Inc., New York, USA), another recently-developed, low-attenuated, 0.1% barium suspension, has proved to be excellent for both GI distension and mural visualization[13,14]. Unfortunately, VoLumen is not available in Thailand. Therefore, its efficacy was not analyzed in the present study. However, Koo et al[12] reported that there was no significant difference in GI distension and mural visualization between VoLumen and whole milk. Furthermore, milk had a lower cost, better patient acceptance, and fewer adverse reactions.

The present study had some limitations. First, the grading on GI distension, mural visualization, GI landmark distinction, taste, patients' satisfaction, and adverse effects are subjective, not based on solid criteria. Furthermore, the authors recognized that GI distension had an effect on both mural visualization and GI landmark distinction. Therefore, the grading of either mural visualization or GI landmark distinction that the radiologists offered was partly influenced by another cause. Second, the sample size was small. Another study with a larger sample size should be performed to get the more reliable data. Third, though the authors did not give the information about the type of received contrast agents to the radiologists, they could identify them easily in cases of diluted iodine contrast because of their high-density content. When seeing low-attenuated contrast with full gastric distension and collapsed gallbladder, the radiologists could guess that one type of whole milk was an oral contrast. Therefore, the type of received contrast agent could not be perfectly blinded.

In conclusion, pasteurized whole milk was superior to other agents in the GI distension and tended to be better than other agents in mural visualization and GI landmark distinction. Unfortunately, gallbladder collapse was inevitable. GI adverse effects were also more common with milk than other agents. These inferior drawbacks of milk should be considered thoroughly before applying milk as a routine CT oral contrast for Thai patients.

**Potential conflicts of interest**

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## *การศึกษาเปรียบเทียบสารน้ำ 4 ชนิดที่ใช้ดื่มเพื่อช่วยในการประเมินระบบทางเดินอาหารด้วยเครื่องเอกซเรย์คอมพิวเตอร์*

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***วัตถุประสงค์:*** *เพื่อเปรียบเทียบสารน้ำ 4 ชนิด (นมพาสเจอร์ไรซ์, นมยูเอชที, น้ำเปล่า และสารทึบรังสีเจือจาง) ที่ใช้ดื่มเพื่อช่วยในการประเมินระบบทางเดินอาหารด้วยเครื่องเอกซเรย์คอมพิวเตอร์ ทั้งในด้านการขยายตัว, ผนัง, และการแยกส่วนต่าง ๆ ของทางเดินอาหาร ตลอดจนรสชาติของสารน้ำ, ความพึงพอใจของผู้ป่วย, ผลข้างเคียง และราคา*

***วัสดุและวิธีการ:*** *ผู้ป่วย 60 ราย ที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์ของช่องท้องถูกแบ่งออกเป็น 4 กลุ่ม แต่ละกลุ่มดื่มสารน้ำจำนวน 1,000 มิลลิลิตร ก่อนการตรวจ (กลุ่ม 1: นมพาสเจอร์ไรซ์, กลุ่ม 2: นมยูเอชที, กลุ่ม 3: น้ำเปล่า และกลุ่ม 4: สารทึบรังสีเจือจาง) การขยายตัว, ผนัง, และการแยกส่วนต่าง ๆ ของทางเดินอาหาร ถูกประเมินโดยรังสีแพทย์ 2 คน ผู้ป่วยแต่ละรายประเมินรสชาติและความพึงพอใจต่อสารน้ำที่ตนได้รับ ส่วนผลข้างเคียงถูกประเมินจากอาการในระบบทางเดินอาหาร (คลื่นไส้, อาเจียน, ปวดแน่นท้อง และท้องเสีย) หลังได้รับสารน้ำ*

***ผลการศึกษา:*** *นมพาสเจอร์ไรซ์มีประสิทธิภาพเหนือกว่าสารน้ำชนิดอื่นในการขยายตัวของระบบทางเดินอาหาร และมีแนวโน้มดีกว่าสารน้ำชนิดอื่นในการประเมินผนังและการแยกส่วนต่าง ๆ ของทางเดินอาหาร ส่วนรสชาติและความพึงพอใจของผู้ป่วยไม่แตกต่างกันชัดเจน กลุ่มที่ได้รับนม (ทั้งพาสเจอร์ไรซ์และยูเอชที) พบมีการหดตัวของถุงน้ำดีและผลข้างเคียงมากกว่าสารน้ำชนิดอื่น สำหรับราคานมพาสเจอร์ไรซ์, นมยูเอชที, น้ำเปล่า และสารทึบรังสีเจือจาง มีราคา 42, 40, 14, และ 36 บาทตามลำดับ*

***สรุป:*** *นมพาสเจอร์ไรซ์ช่วยในการประเมินระบบทางเดินอาหารได้ดี ทั้งในด้านการขยายตัว, ผนัง, และการแยกส่วนต่าง ๆ ของทางเดินอาหาร อย่างไรก็ตามมีข้อจำกัดเนื่องจากทำให้ถุงน้ำดีหดตัว และยังพบผลข้างเคียงในระบบทางเดินอาหารได้บ่อย โดยเฉพาะในผู้ป่วยคนไทยที่ไม่คุ้นเคยกับการดื่มนมปริมาณมาก*