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Oral contrast media for computed tomography of canine pancreas

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Abstract : Barium suspension, oral iodine contrast medium and water were applied in eight dogs to evaluate (1) distension of gastrointestinal tract, (2) the effect of the oral contrast media on the identification of the pancreas from surrounding organs, and (3) image quality and the presence of artifacts in canine pancreas computed tomography (CT) images. Oral iodine contrast medium, gastrografin, produced significant artifacts that deteriorated the CT images of the pancreas. The use of water did not provide the fullness of the gastrointestinal lumens. Barium suspension was effective for the identification of the pancreas from the surrounding gastrointestinal tract, without significantly increasing image noise. Barium suspension can be used as an optimal contrast medium that will not cause an adverse effect on the pancreatic density and image quality.

Keywords : barium, computed tomography, dog, oral contrast media, pancreas

Introduction

Use of an oral contrast medium for the computed tomography (CT) examination is recommended in most abdominal cases in human patients, and a positive oral contrast medium such as a dilute barium suspension or water-soluble contrast medium containing iodine is conventionally and effectively used [8, 9, 11, 13]. Water and less commonly fat density products such as corn oil and milk can be used as negative contrast media [2, 6, 9, 13]. The essential requirements of oral contrast media should not produce artifacts [12].

The CT examination has been considered as the standard method for pancreatitis [1, 3, 5, 7]. However, even in CT images, a contracted and unenhanced duodenum may mimic a pancreatic mass and oral contrast media can be required to examine the pseudo-tumor effect of the emptying gastrointestinal tract and for the evaluation of the resectability of a pancreatic tumor from the surrounding gastrointestinal tract [12].

We performed this study to investigate the applicability of contrast media to distinguish the pancreas from the adjacent gastrointestinal tract, and to choose an oral contrast medium that produced the least effect on the density of the pancreas and produced minimal artifacts that interfered with the image quality.

Materials and Methods

Animals

Eight mature, adult beagle dogs weighing 8~14 kg were utilized without distinction of gender. They were clinically healthy based on physical examination, complete blood count and serum biochemistry (normal levels of aspartate aminotransferase, alkaline phosphatase, albumin, total bilirubin, total protein, blood urea nitrogen, creatinine, amylase, lipase, calcium, phosphorus, cholesterol). The dogs were fed commercial food and tap water *ad libitum* and fasted 24 h prior to the CT examination. Dogs were cared for according to The Guide for the Care and Use of Laboratory Animals at the Seoul National University, Korea.

Oral Contrast Media

All dogs were used three times in turn according to contrast media at one-week interval. Barium suspension (Barium 1.5%, Easy-CT; TaeJun, Korea), gastrografin (Gastrografin 2%; Schering, Korea) and water were

used. All dogs were administered a volume of 50 mL of an oral contrast agent 30 min before CT imaging and an additional volume of 20 mL just prior to the examination through the use of a gastric tube by modified previously described protocol [6].

CT Scanning

After oral contrast medium administration, general anesthesia was induced with 0.5 mg/kg diazepam (Merode; Donghwa, Korea) and 6 mg/kg propofol (Pofol; Dongkook, Korea) intravenously, and maintained with isoflurane (Isoflurane; Rhodia Organique Fine, UK). With the dog in dorsal recumbency, CT images were acquired using a CT-e unit (GE Medical Systems, USA) from the tenth thoracic vertebral region to third lumbar vertebral region. Helical sequences were acquired using 120 kVp and 80 mA with 2 mm slice thickness and 1.5 pitch factor in all scans. The field of view ranged between 150 and 220 mm. The dogs were hyperventilated with positive pressure ventilation prior to each scan to produce a period of apnea and avoid motion artifacts.

Image Analysis

All CT images were evaluated at a window width of 400 and a window level of 40 Hounsfield units (HU). The CT images were analyzed separately at the workstation, each by three different radiologists (Choi JH, Chang JH, and Oh SK). The images were presented unpaired and arbitrarily to the reviewers, who were unaware of any image information other than the window setting. The image findings were recorded on standardized data sheets. Each reviewer scored the luminal distension at four sites—the proximal stomach, distal stomach, duodenum, and the jejunum—using a three point scale (1: poor, 2: adequate, 3: excellent). The reviewers, using the same scale, evaluated the anatomical conspicuity of the proximal and distal stomach, duodenum, pancreas, liver, portal structures, and the jejunum. An artifact was evaluated with a three point score system (1: barely perceptible, 2: noticeable, 3: interpretation limit). The HU value of the pancreas was measured for quantitative assessment of the effect of oral contrast media on the pancreas. An ellipsoid region of interest was drawn over three regions of the pancreatic body under the field of the gastrointestinal tract containing contrast media per a dog, and recorded as a mean and standard deviation. HU value of the pancreas in each contrast agent was compared with HU values

of the pancreas in CT images without oral contrast agent.

Statistics

Mean values from subjective scores and objective values were calculated per the pancreatic images and reviewer for the use of the oral contrast media. Median score differences and objective value differences among the oral contrast types were calculated per image. Two-way ANOVA tests were performed to evaluate differences in scores among the used contrast media and among the reviewers. The HU values of the pancreas in animals given water and in animals given the barium suspension were compared by one-sample statistics. P-values less than 0.05 were considered statistically significant.

Results

Four of total twenty four CT image sets were excluded from this study due to technical problems such as severe motion artifact and a large amount of luminal gas in gastrointestinal tract. In an axial image, the gastrointestinal loops were hyperattenuated with positive contrast media and hypoattenuated with negative contrast medium (Fig. 1). This change of attenuation made the wall of gastrointestinal tract identifiable from the pancreas. Gastrointestinal distention and fullness were optimal in dogs given gastrografin ($p < 0.001$) (Table 1). There was good interobserver agreement with a 4/4 consensus achieved for 20 images. The anatomical conspicuity of the proximal stomach, distal stomach, and the first two parts of the duodenum, the pancreas, the liver, the portal vein and the jejunum was significantly better with barium suspension than gastrografin and water ($p < 0.05$) (Table 2). There was good interobserver agreement with a 5/7 or 7/7 consensus achieved, respectively. Several broad hypoattenuating streaks superimposed on the pancreas were visible (Fig. 2). The

Table 1. Score for the gastrointestinal distention and fullness assessments according to oral contrast media

	Barium	Gastrografin	Water
Proximal stomach	1.94	2.30*	2.00
Distal stomach	1.88	2.30*	1.75
Duodenum	2.13	2.75*	1.50
Jejunum	1.88	2.65*	1.38

1: poor, 2: adequate, 3: excellent.
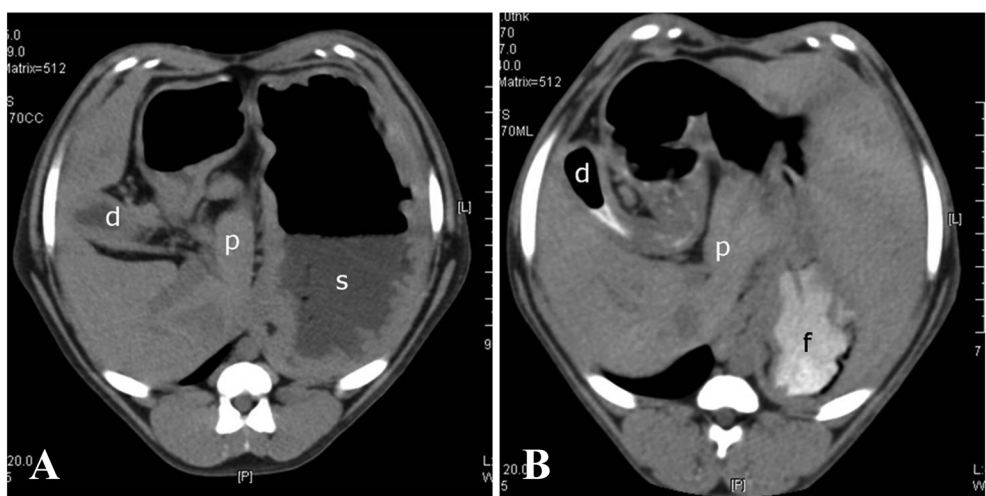*Significant difference ($p < 0.001$). All data is presented as means.

Fig. 1. Axial CT section through the upper abdomen in a normal dog after ingestion of 70 mL of water (A) and barium (B) as oral contrast medium. Each agent is identified as hyperattenuating and hypoattenuating in gastrointestinal lumen, respectively, and discriminates the pancreas (p) from the stomach (s), gastric fundus (f) and duodenum (d).

Table 2. Score for identification of the pancreas and adjacent organs in oral contrast enhanced CT image

	Barium	Gastrografin	Water
Proximal stomach	2.50*	2.30	2.19
Distal stomach	2.56*	2.25	2.19
Duodenum	2.75*	2.20	2.06
Pancreas	1.94*	1.50	1.88
Liver	2.69*	2.20	2.44
Portal structures	2.25*	1.70	2.13
Jejunum	2.13*	2.10	1.94

1: barely perceptible, 2: noticeable, 3: interpretation limit.
*Significant difference ($p < 0.05$). All data is presented as means.

severity of these artifacts varied according to an anatomic location in the same dog. In general, streaks were more pronounced in dogs given gastrografin, and the median artifact score was 2.10, which was significantly higher than score of barium suspension (1.50) and water (1.13) ($p < 0.001$). Water caused no artifact for a CT image as compared with barium ($p < 0.05$). In the quantitative assessment of artifacts, the HU value of the pancreas was 53 ± 4.83 with barium suspension and 52 ± 5.41 with water, and there was no significant difference from the HU of the pancreas, 52 ± 4.58, with no contrast agent. However, the HU values of the pancreas for the dogs given gastrografin had a wide variation, so a significantly consistent HU value

Fig. 2. Axial CT section through the upper abdomen in a normal dog after ingestion of 70 mL of gastrografin. The streak artifact is observed overall CT image and the pancreas cannot be identified from surrounding structures.

of pancreas could not be measured. The readers agreed on these observations for 75~83% of the 20 images.

Discussion

We applied a modified protocol from a gastrointestinal study in human, in which a volume of 400 mL of oral contrast agent is ingested from 40 min to 1 h before imaging and an additional volume of 200 mL is ingested

20 min just prior to the examination [12]. Because this study used oral contrast media for the pancreas CT examination, we reduced volume of contrast media to prevent over-distension and fullness of the stomach and duodenum, which can obscure the pancreas.

The gastrointestinal tract was distended fully enough to identify each other structure and a good coating of the mucous membranes was achieved with the use of the barium suspension and gastrografin. However, rapid passage of water results in inferior distention of the duodenum and difficulties in discrimination from the pancreas. Muscle relaxants such as buscopan can be used to delay the passage of water in the gastrointestinal tract, but even with the use of a muscle relaxant does not provide as good quality images as the use of positive contrast media [12]. Mural visualization with the use of water was inferior to positive contrast media, which have an inherent contrast between mural density and contrast density. Although it is inconvenient but, a contrast enhanced CT scanning with an iodinated intravenous contrast agent can be used concurrently with oral contrast study to compensate a low contrast of water for the gastrointestinal tract through enhancing the mucosal layer [13].

Positive contrast media may increase the local absorbed dose of the X-ray beam in the intestinal mucosa by as much as five times as a result of photoelectric interactions at the contrast agent-mucosa interface, and the streak artifact was exaggerated in dogs given positive contrast media [5]. Gastrografin produced significantly more hypoattenuating linear artifacts than barium suspension, which obscured the depiction of the pancreas on CT images.

It can be presumed that because of the irregular distribution of gastrografin and its high density, a small but highly attenuating agent, that only a part of the slice width, may cause both a partial volume artifact and beam hardening. Gastrografin reduced the HU value of the pancreas, so the HU value of the pancreas could not be used as a relatively objective factor to identify the pathologic lesion in pancreatic parenchyma. This artifact can be an obstacle to evaluate pancreatitis with local complications such as focal fluid collection, a pancreatic pseudocyst and necrosis or a pancreatic mass. To reduce this artifact, a reconstruction algorithm can be used to correct for beam hardening changes [5]. By reducing the slice thickness, fewer attenuation changes are encompassed within the slice volume and a partial volume artifact can

be minimized [4]. However, decreasing the slice thickness increases image noise, which is evident as graininess and reformatting requires considerably more slices per a pancreas scan, resulting in longer scan time and increased tube load [10]. CT images could be obtained without a streak artifact with water [9].

This study has limitation that the evaluation of the pancreas CT images was not performed according to various amounts of contrast media. Fatty agents such as milk or corn oil emulsion were not evaluated in this study, because these agents have a high caloric content and fat, which is not suitable for use in patients with acute pancreatitis [9, 12]. Milk contains relatively low calories and low fat, but it necessitates the use of an intravenous contrast agent like with water [12].

Conclusion

The best mural visualization and gastrointestinal distension were achieved with the use of the barium suspension and gastrografin. Gastrografin produced noticeable streak artifacts and affected the pancreatic density, so it cannot be the first choice for the examination of the pancreas. The use of barium suspension for CT of the canine pancreas enhanced diagnostic quality without a significant increase in image noise. Water can considered to be used with a contrast enhanced CT with intravenous contrast medium, and distention of the bowel with a muscle relaxant.

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