Frequency of Common Bile Duct Motion Artifacts Caused by Inferior Vena Cava Pulsation on Magnetic Resonance Cholangiopancreatography

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Purpose: We assessed the frequency of common bile duct (CBD) motion artifacts caused by inferior vena cava (IVC) pulsation on magnetic resonance cholangiopancreatography (MRCP).

Methods: We retrospectively evaluated CBD motion artifacts in 4 MRCP sequences from each of 115 consecutive patients.

Results: We observed 37 (32.2%) ghost artifacts at the ventral and dorsal aspects of the CBD on transaxial, half-Fourier acquisition single-shot turbo spin-echo (HASTE-ax) images; no such artifacts were observed on transaxial T2-weighted turbo spin-echo images. In 10 patients, we observed 9 (7.8%) pseudo-defects of the CBD on 3-dimensional T2-weighted turbo spin-echo with navigator-triggered prospective acquisition correction (PACE) technique MRCP and 6 (5.2%) pseudo-defects on single-shot rapid acquisition with relaxation enhancement MRCP. Pseudo-defects were significantly more frequent in patients with ghost artifacts than without (9 of 37 [24.3%] versus one of 78 [1.3%]; P < 0.01, McNemar test).

Conclusion: Although uncommon, pseudo-defects of the CBD caused by IVC pulsation are observed on MRCP. MRCP interpretation that includes comparison with HASTE-ax images can diminish the potential misinterpretation of such CBD motion artifact as bile duct tumor or biliary stone.

Keywords: artifact, common bile duct, inferior vena cava, magnetic resonance imaging

Introduction

Various artifacts have been reported in magnetic resonance cholangiopancreatography (MRCP).1,2 Among the most common artifacts, those from respiratory motion can be reduced by using techniques that shorten acquisition time3–5 or by correcting respiratory motion utilizing a recently developed free-breathing navigator-triggered prospective acquisition correction (PACE) technique.6,7 However, despite satisfactory breath-holding or navigator-triggering, findings resembling motion artifacts are occasionally observed at the extrahepatic bile duct.8,9

Among such findings, pseudo-obstruction of the extrahepatic bile duct caused by artifact from arterial pulsatile compression is well known.2,8 However, the back-and-forth motion of the anterior wall of the inferior vena cava (IVC) during the cardiac cycle can also produce motion artifacts of the common bile duct (CBD), which borders the IVC.9–11

The frequency and appearance of this artifact differs among the different magnetic resonance (MR) imaging sequences because of the character
of CBD movement. The back-and-forth motion of the CBD has been reported to cause ghost artifacts at the ventral and dorsal aspects of the CBD on transaxial MR imaging and pseudo-defects on MRCP; however, the frequency of these findings in clinical cases is not reported.

Failure to acknowledge the presence of this CBD motion artifact may lead to its misinterpretation as an abnormal finding, such as bile duct tumor or biliary stone, because the image quality of other tissues is not affected. Because it is crucial to clarify the presence of CBD motion artifact in interpreting CBD images, we retrospectively evaluated the frequency of CBD motion artifacts resulting from IVC pulsation that depended on the cardiac cycle on MRCP.

Materials and Methods

Patients

This retrospective, single-institution study was approved by the institutional review board of this facility. Informed written consent was not required. A radiologist (A) conducted a computer search to identify all MRCP examinations conducted between September and November 2006. Images from only the first examination for each patient were included in the review; no cases were excluded. The final study group consisted of 115 patients (57 women, 58 men; median age, 62 years, range 21–89). The reasons for referral for MRCP examination included gallbladder or biliary stone (n = 33), pancreatitis (n = 17), pancreatic cancer (n = 15), post cholecystectomy (n = 10), pancreatic cystic tumor (n = 8), elevated serum bilirubin enzyme level (n = 8), dilatation of bile duct (n = 6), fever (n = 5), abdominal or back pain (n = 5), dilatation of pancreatic duct (n = 4), and other tumors (n = 4).

MR imaging technique

MR imaging examinations were performed using a commercially available 1.5T system (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany) and a 6-element body phased-array coil as the radiofrequency receiver. All patients were instructed to fast one meal before MR examination and were administered 1200 mg of ferric ammonium citrate (FerriSeltz; Otsuka Pharmaceutical, Tokushima, Japan) in 100 mL of water as a negative oral contrast agent.

After acquisition of scout images, 4 MR imaging sequences of the biliary region were acquired: multislice half-Fourier acquisition single-shot turbo spin-echo (HASTE); T2-weighted turbo spin-echo (T2-TSE); single thick-slab rapid acquisition with relaxation enhancement (RARE); and 3-dimensional T2-TSE with navigator-triggered PACE.

The multislice HASTE transaxial (HASTE-ax) images were acquired during 2 breath-holds using a concatenation technique with the following parameters: repetition time (TR)/effective echo time (TE), 1500/79 ms; echo spacing, 5.64 ms; flip angle, 150°; bandwidth, 349 Hz/pixel; matrix, 256 × 256; turbo factor, 208; phase-partial Fourier factor, 5/8; field of view (FOV), 320 mm; section thickness, 7 mm; gap, 1.75 mm; number of slices, 19; phase-encoding direction, anterior to posterior; number of averages, 1; and acquisition time per concatenation, 15 s. Fat saturation was not used.

The T2-TSE transaxial (T2-TSE-ax) images were acquired during 2 breath-holds using a concatenation technique with the following parameters: TR/effective TE, 2800/79 ms; echo spacing, 8.78 ms; flip angle, 150°; bandwidth, 230 Hz/pixel; matrix, 256 × 166; turbo factor, 23; FOV, 320 mm; section thickness, 7 mm; gap, 1.75 mm; number of slices, 19; phase-encoding direction, anterior to posterior; number of averages, 1; and acquisition time per concatenation, 20.5 s. Fat saturation was not used.

The slabs of the RARE MRCP (RARE-MRCP) images were acquired at various angles during a single breath-hold, with 4 to 8 (mean, 6) thick-slab acquisitions per patient. The imaging parameters for RARE-MRCP were TR/effective TE, 5000/699 ms; echo spacing, 7.52 ms; flip angle, 180°; bandwidth, 200 Hz/pixel; matrix, 384 × 192; turbo factor, 192; FOV, 320 mm; slab thickness, 70 mm; phase-encoding direction, variable depending on slice direction; number of averages, 1; and acquisition time, 6.5 s. Fat saturation was used.

Three-dimensional T2-TSE with navigator-triggered PACE MRCP (PACE-MRCP) images were acquired in the coronal plane during free breathing with the following parameters: TR/TE, 1 × the respiratory cycle/603 ms; echo spacing 7.44 ms; flip angle, 170°; bandwidth, 300 Hz/pixel; matrix, 256 × 218; turbo factor, 129; FOV, 280–375 mm; section thickness, 1.5 mm; number of slices, 48; phase-encoding direction, right to left; and number of signals acquired, 1. Fat saturation was used.

The navigator echoes of a gradient-echo, fast low-angle shot (FLASH) sequence continuously acquired a coronal 2-dimensional image to monitor the movement of the right diaphragm, using a standard protocol and the following parameters: flip angle, 3°; TR, 150 ms; and search range, ±2.0 mm. Data of the end-expiratory phase were gathered via navigator-triggering. The acquisition time, which depended on the patient’s respiration cycle, ranged from 3 to 13 min. Maximum-intensity-projection (MIP) images rotated about the cranio-inferior
caudal and horizontal axes were reconstructed from these images.

Image analysis

Two radiologists (A, B), each with more than 5 years’ experience in evaluating MRCP examinations and each initially blinded to the patients’ medical histories and final diagnoses, reviewed the MR images in consensus using a commercially available viewer (Centricity RA1000; GE Healthcare, Milwaukee, WI, USA). In each of the stages below, the images were reviewed in different sequential order by patient name, date of acquisition, medical record number, and patient age, respectively.

First, the T2-TSE-ax image was reviewed regarding the presence of ghost artifact at the CBD; the HASTE-ax image was then reviewed in the same manner. The 2 radiologists established the criterion for the presence of this artifact as band-like abnormal signal intensities, very low or high, at the ventral and dorsal aspects of the CBD bordering the IVC. After these interpretations, we found that no such artifact was observed on the T2-TSE-ax images; therefore, the T2-TSE-ax image was used as a reference image in the next step.

Second, RARE-MRCP images were reviewed for the presence of a defect at the CBD; the PACE-MRCP image was then reviewed in the same manner. For those patients with defects, pseudo-defects of the CBD caused by IVC pulsation were identified and investigated. The 2 radiologists established the criteria for the presence of this artifact as: (a) a focal, poorly detected area at the CBD; (b) no change in caliber of the CBD above and below this area; (c) appearance different from that of a pseudo-obstruction caused by arterial pulsatile compression, which is usually observed at the common hepatic duct as a characteristic band-like defect; and (d) no other abnormalities of the CBD detected by other examinations, such as endoscopic retrograde cholangiopancreatography (ERCP) and computed tomography (CT). The examination used to confirm the final diagnosis was recorded. If no other examinations were performed, the T2-TSE-ax image was used as a reference, and the follow-up period between the MRCP examination and the most recent medical examination was recorded.

Statistical analysis

McNemar’s test was used to compare the frequency of the ghost artifacts observed on the transaxial images and the pseudo-defects observed on the MRCP images. Statistical analyses were performed using computer software (SPSS, student version 13.0J; SPSS, Chicago, IL, USA). A P value less than 0.05 was considered statistically significant.

Results

Among the 115 patients, 37 (32.2%) ghost artifacts were observed at the ventral and dorsal aspects of the CBD on HASTE-ax images (Figs. 1, 2). No such artifact was observed on T2-TSE-ax images. In 10 patients, we observed 9 (7.8%) pseudo-defects of the CBD on the PACE-MRCP images and 6 (5.2%) on the RARE-MRCP images (Figs. 1, 2). Pseudo-defects on the MRCP images were significantly more frequent in patients with ghost artifacts on HASTE-ax than in patients without (9 of 37 [24.3%] versus one of 78 [1.3%], p < 0.01). Of the 10 patients diagnosed with pseudo-defects on MRCP, we excluded possible other abnormalities with regard to the CBD using ERCP (n = 3), computed tomography (CT; n = 3), and the T2-TSE-ax image (n = 4; mean follow-up, 4.9 months). Nine true defects of the CBD were also observed, six caused by CBD stones diagnosed by ERCP (n = 4) and CT (n = 2) and three caused by tumors (CBD cancer, 2; pancreas cancer, 1) diagnosed by ERCP (n = 2) and CT (n = 1).

Discussion

The anterior-posterior diameter of the IVC is known to change depending on both the phase of respiration and the cardiac cycle.9–11 A study of healthy volunteers found that many CBDs move back and forth in synchronization with the IVC anterior wall motion during electrocardiography-triggered cine MR imaging.9 The relatively high rate of characteristic ghost artifacts observed on the HASTE-ax images in the present study supports this fact; the likelihood of the artifact being observed depends on the MR imaging sequence and the individual degree of CBD motion.

In the present study, ghost artifacts were observed at the CBD on HASTE-ax but not on T2-TSE-ax images. These artifacts resemble the ghost artifact caused by aortic pulsation that is usually observed on contrast-enhanced gradient-echo sequences in the phase-encoding direction of the aorta.12,13 HASTE is a rapid sequence generally believed to reduce artifacts by shortening the acquisition time, especially for respiratory-motion artifacts.3–5 However, the substantial signal acquisition time of a single HASTE-ax slice (5.64 ms [echo space] × 208 [turbo factor] × 5/8 [phase-partial Fourier factor]) = 733.2 ms) is relatively long, reflecting the character of a single-shot sequence, when compared to the T2-TSE-ax acquisition time

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Fig. 1. Common bile duct motion artifact demonstrated on magnetic resonance cholangiopancreatography (MRCP) images in a 51-year-old woman with gallstones. 

a: A pseudo-defect (arrow) is indicated at the common bile duct on the maximum-intensity-projection (MIP) image from 3-dimensional T2-weighted turbo spin-echo (T2-TSE) MRCP using a free-breathing, navigator-triggered prospective acquisition correction technique. 
b: A pseudo-defect (arrow) is also indicated at the common bile duct in a single thick-slab, rapid acquisition with relaxation enhancement (RARE) image. 
c: Ghost artifact is indicated at the ventral and dorsal aspects of the common bile duct (arrow) that borders on the inferior vena cava (arrowhead) in a transaxial half-Fourier acquisition, single-shot turbo spin-echo (HASTE) image. The appearances of this image imply that the pseudo-defects in a and b (arrows) may also be motion artifacts caused by inferior vena cava pulsation.

(8.78 ms [echo space] × 23 [turbo factor] = 201.94 ms). Therefore, rapid movement during the cardiac cycle can produce an artifact on HASTE-ax that would not be apparent on T2-TSE-ax images because of the shorter signal acquisition time and signal averaging of multiple-shot imaging. The artifact will be further emphasized because the back-and-forth CBD movement corresponds to the phase-encoding direction, which is the direction susceptible to motion.12,13

Pseudo-defects on the MRCP images can be attributed to CBD movement based on their statistical relevance to ghost artifacts on HASTE-ax, which would be natural because signals of moving tissues are usually decreased. However, CBD motion artifacts have not been reported until recently. Such artifacts are unclear on RARE-MRCP, as revealed in the present study. The substantial signal acquisition time per one slice of RARE-MRCP (7.52 ms [echo space] × 192 [turbo factor] = 1443.84 ms) is longer than that of HASTE-ax (733.2 ms); however, because the thickness of one slice of RARE-MRCP is thicker than that of HASTE-ax, these artifacts are obscured on RARE-MRCP im-
Fig. 2. Common bile duct motion artifact demonstrated on magnetic resonance cholangiopancreatography (MRCP) images in a 54-year-old man with gallstones.

a: A pseudo-defect (arrow) is indicated at the common bile duct on a maximum-intensity-projection (MIP) image from 3-dimensional T₂-weighted turbo spin-echo (T₂-TSE) MRCP using a free-breathing, navigator-triggered prospective acquisition correction technique. 
b: The pseudo-defect is not observed on the single thick-slab, rapid acquisition with relaxation enhancement (RARE) image.
c: Ghost artifact is indicated at the ventral and dorsal aspects of the common bile duct (arrow) that borders on the inferior vena cava (arrowhead) in a transaxial half-Fourier acquisition, single-shot turbo spin-echo (HASTE) image.

Another reason why such artifacts are unclear on conventional respiratory-triggering MRCP is that they are obscured by inextinguishable respiratory-motion artifact. Following the recent development of the free-breathing navigator-triggered PACE technique, respiratory-motion artifacts can be successfully reduced by directly monitoring diaphragmatic movement; consequently, CBD motion artifacts become apparent on PACE-MRCP images.

In the present study, no case with pseudo-defects of the CBD was clinically misinterpreted or mistreated as bile duct tumor or biliary stone because all MR images at our institution, including T₂-TSE-ax and HASTE-ax images, were routinely interpreted together. An understanding that IVC pulsation can cause CBD motion artifacts on MRCP is crucial and facilitates diagnosis of CBD pseudo-defects. Findings indicative of a pseudo-defect are: a focal, poorly visualized area of the CBD with no caliber change above or below demonstrated on MRCP; no such defect on transaxial images; and the presence of a ghost artifact at the ventral and dorsal aspects of the CBD on the HASTE-ax image.

The present study was limited because the CBD movement that caused the artifact was not directly observed in any case. Electrocardiography-trig-
gered cine MR imaging would enable the motion to be visualized and proved directly; however, as mentioned, interpretation of all MR images taken together is sufficient for differential diagnosis of CBD motion artifact clinically, especially for ascertaining characteristic ghost artifact on the HASTE-ax images. Proving the existence of a pseudo-defect does not require invasive examinations, such as ERCP, but can be achieved by simply attaching an electrocardiography monitor to the patient and immediately obtaining cine MR imaging.

Another limitation of the study was the absence of ERCP verification of diagnoses of pseudo-defect confirmed by excluding the possibility of other abnormalities at the CBD. Some were diagnosed by CT and even by T₂-TSE-ax; however, we considered it neither valid nor, indeed, necessary to subject patients to invasive examinations in the absence of clinical symptoms concerning the CBD.

Conclusion

Although infrequent, pseudo-defects of the CBD resulting from IVC pulsation are observed on MRCP. The evaluation of MRCP images and comparison with HASTE-ax images, which indicate characteristic ghost artifacts at the ventral and dorsal aspects of the CBD, would diminish the potential for misinterpretation of CBD motion artifact as bile duct tumor or biliary stone.

References