

Physiological Bile Flow in the Extrahepatic Bile Duct: Evaluation with Cine-Dynamic MR Cholangiopancreatography and a Spatially Selective Inversion-Recovery Pulse

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Target audience: Radiologist, physician.

Purpose: The purpose of this study was to determine the feasibility of directly and noninvasively visualizing physiological bile flow in the extrahepatic bile duct by means of non-pharmacologic cine-dynamic MR cholangiopancreatography (MRCP) with a spatially selective inversion-recovery (IR) pulse and to assess the flow dynamic pattern of bile in the extrahepatic bile duct.

Methods: Thirty-five patients without known pancreatobiliary diseases (nondilated group) and 11 patients with dilatation of the extrahepatic bile duct (dilated bile duct group) were included. A breath-hold, thick-slab 2D MRCP image was obtained in combination with a spatially selective IR pulse (inversion time=2200msec) of 20mm width placed as perpendicularly as possible to the lower common bile duct (Figure1) to observe the movement of the bile in the common bile duct. With this technique, antegrade bile flow entering the area of the IR pulse from the proximal side of the extrahepatic bile duct is fully magnetized and shows high signal intensity (Fig.1a), while the static bile in the area of the IR pulse is nulled and appears as a dark area of low signal intensity. Conversely, reversed bile flow going out from the area of the IR pulse to the proximal side of the extrahepatic bile duct is seen as a dark area of low signal intensity just outside the area of the IR pulse (Fig.1b). Cine-dynamic MRCP with a spatially selective IR pulse was performed by scanning every 15 seconds over a 5-minute interval (total of 20 images) to analyze the flow dynamic pattern of bile in the extrahepatic bile duct. The images were evaluated for the visualization of antegrade/reversed bile flow, how frequently antegrade/reversed bile flow was observed in the extrahepatic bile duct, and how far the antegrade/reversed bile moved in the bile duct (graded according to the distance that the bile moved as follows; grade 0 = no flow, grade 1 = less than 5mm, grade 2 = 5-10 mm, grade 3 = 11-15 mm, and grade 4 = more than 15 mm). Statistical analysis was performed by using Spearman rank correlation coefficient and Mann-Whitney U tests.

Results: The antegrade bile flow was observed in 29 of 35 (83%) patients in the nondilated group while it was seen in 5 of 11 (46%) patients in the dilated bile duct group ($p=0.014$). Antegrade bile flow was observed much more frequently in the nondilated group than in the dilated bile duct group (4.4 times vs 1.8 times, $p=0.029$). The distance that bile moved forward within the area of the IR pulse was significantly greater in the nondilated group than in the dilated bile duct group (mean grade: 0.44 vs 0.14, $p=0.033$), suggesting stagnation or slow-down of antegrade bile flow in patients with biliary dilatation. There was no regularity in the distance (grade) of antegrade bile flow between images in the same subject. The reversed bile flow was also observed in 26 of 35 (74%) patients in the nondilated group without biliary diseases, suggesting that retrograde movement of bile in the extrahepatic bile duct is a physiological phenomenon, and may be caused by the counteractive movement of bile induced by contraction of the sphincter of Oddi. The mean frequencies of observation of reversed bile flow in the extrahepatic bile duct in the nondilated group without biliary diseases were 2.3 times (range; 0-9 times) in a series of 20 images (acquisitions), while they were 1.7 times (range; 0-5 times) in the dilated bile duct group. There was no significant difference in the frequency of observation of reversed bile flow between the nondilated and dilated bile duct group ($p=0.594$). Additionally, there was no statistically significant difference in the distance traversed by the reversed bile flow between the nondilated (mean grade, 0.18; range, 0-1.45) and dilated bile duct group (mean grade, 0.10; range, 0-0.35) ($p=0.476$), suggests that contractility of the sphincter of Oddi may be preserved in patients with biliary dilatation, while stenosis of the ampulla of Vater may be induced by hypertrophy of fibrous tissue within the sphincter of Oddi.

Conclusion: Non-pharmacological, cine-dynamic MRCP with a spatially selective IR pulse allows direct and noninvasive visualization of bile flow in the extrahepatic bile duct, demonstrating that reversed bile flow is a physiological phenomenon.

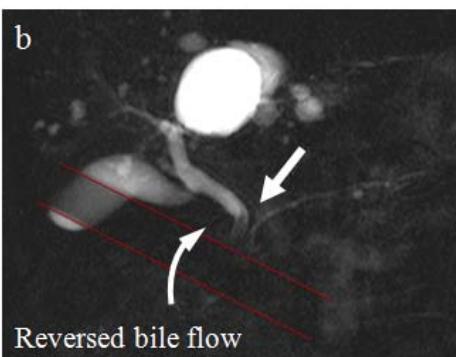
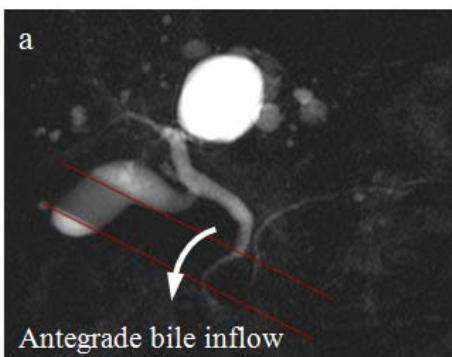


Figure1. Cine-dynamic MRCP with a spatially selective IR Pulse.

a) The 19th image among a series of 20 MRCP. The antegrade bile flow was observed as high signal intensity (arrow) within the area of the IR pulse between the parallel lines. The distance of the antegrade bile inflow was categorized as grade 3.

b) The 13th image among a series of 20 MRCP. The reversed bile flow was observed clearly as an area of low signal intensity (arrow) within the extrahepatic bile duct just proximal to the IR pulse. The distance of the reversed bile flow was categorized as grade 3.