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Dual-energy CT-cholangiography in potential donors for living-related liver transplantation: Improved biliary visualization by intravenous morphine co-medication

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ABSTRACT

Purpose: To prospectively evaluate whether intravenous morphine co-medication improves bile duct visualization of dual-energy CT-cholangiography.
Materials and methods: Forty potential donors for living-related liver transplantation underwent CT-cholangiography with infusion of a hepatobiliary contrast agent over 40 min. Twenty minutes after the beginning of the contrast agent infusion, either normal saline ($n = 20$ patients; control group [CG]) or morphine sulfate ($n = 20$ patients; morphine group [MG]) was injected. Forty-five minutes after initiation of the contrast agent, a dual-energy CT acquisition of the liver was performed. Applying dual-energy post-processing, pure iodine images were generated. Primary study goals were determination of bile duct diameters and visualization scores (on a scale of 0 to 3: 0—not visualized; 3—excellent visualization).
Results: Bile duct visualization scores for second-order and third-order branch ducts were significantly higher in the MG compared to the CG (2.9 ± 0.1 versus 2.6 ± 0.2 [$P < 0.001$] and 2.7 ± 0.3 versus 2.1 ± 0.6 [$P < 0.01$], respectively). Bile duct diameters for the common duct and main ducts were significantly higher in the MG compared to the CG (5.9 ± 1.3 mm versus 4.9 ± 1.3 mm [$P < 0.05$] and 3.7 ± 1.3 mm versus 2.6 ± 0.5 mm [$P < 0.01$], respectively).
Conclusion: Intravenous morphine co-medication significantly improved biliary visualization on dual-energy CT-cholangiography in potential donors for living-related liver transplantation.

1. Introduction

Accurate imaging of the biliary tree is important in the pre-operative assessment of potential donors for living-related liver transplantation [1,2]. Non-invasive techniques used to examine the biliary system, include magnetic resonance imaging (MRI) and computed tomography (CT) [3,4]. Yeh et al. reported significantly better biliary tract depiction in potential donors for living-related liver transplantation with CT-cholangiography compared to conventional and excretory MR-cholangiography [5]. Furthermore, CT-cholangiography accurately detects morphological and functional biliary pathology [6,7]. Multi-phase CT-cholangiography allows for accurate evaluation of vascular and biliary variations in a single diagnostic examination [8]. Innovative CT techniques such as dual-energy can further improve contrast-enhanced imaging of the abdomen [9–11]. In a recent work on dual-energy CT-cholangiography, contrast-optimized images and pure iodine images, both reconstructed on from the dual-energy data, demonstrated superior results compared to conventional images [12]. In the same work, 80-kVp images showed inferior image quality. Delineation of intrahepatic bile ducts is critical in the context of living-related liver donation [13,14]. While diagnostic images of the extrahepatic biliary system are obtained in most patients, delineation of high-order intrahepatic bile ducts is more variable due to non-dilatation [3,5,15]. To optimize biliary imaging, different pharmacological substances have been studied. As morphine is known to cause spasm of the sphincter of Oddi, it might improve visualization of the high-order intrahepatic bile ducts [16,17]. Excellent results have been demonstrated with morphine administration in cholescintigraphy [18]. However, in a retrospective study, premedication of intravenous morphine for CT-cholangiography did not improve biliary caliber and visualization [3]. Thus, the purpose of this study was to prospectively evaluate whether intravenous

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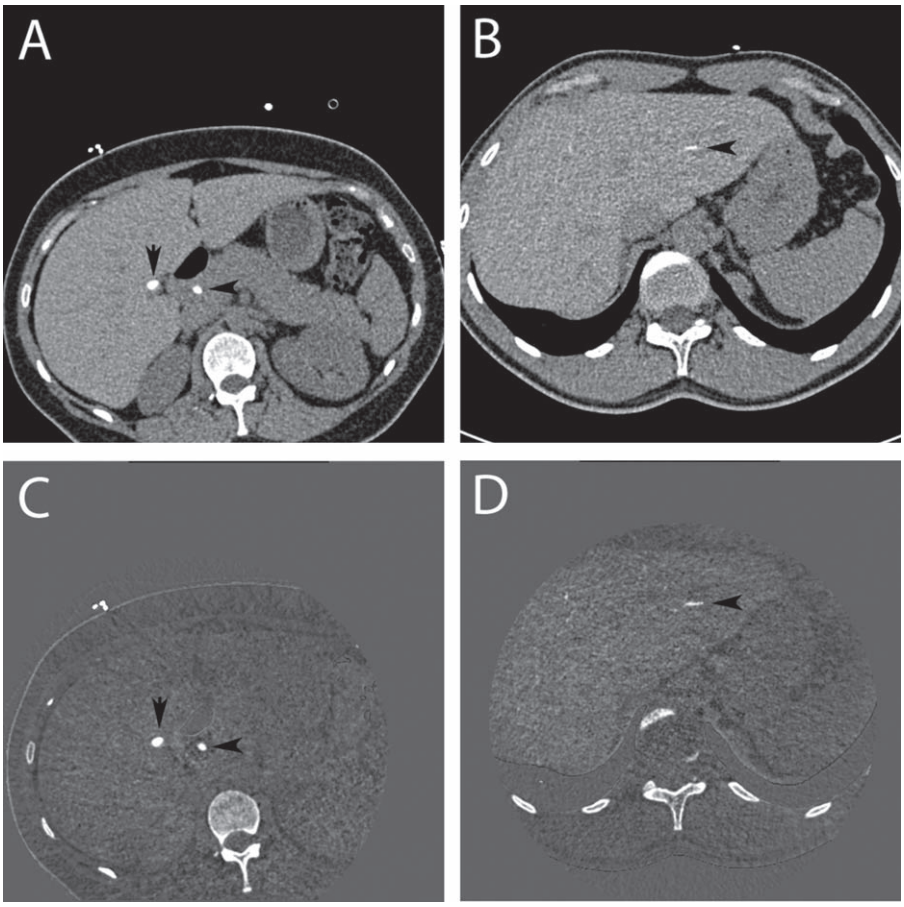

Fig. 1. Pure iodine images (C and D) were reconstructed applying a standard dual-energy post-processing technique. Compare pure iodine images to weighted image datasets (A and B). Note the sharp delineation and excellent contrast of the opacified bile ducts in the pure iodine images (C and D): common duct (black arrowhead) and part of the gallbladder (black arrow) in a subject of the CG. High-order bile duct (black arrowhead) in a subject of the MG (B and D).

morphine co-medication improves biliary visualization of dual-energy CT-cholangiography in potential donors for living-related liver transplantation.

2. Materials and methods

2.1. Subjects

This prospective study was compliant with the requirements of the Health Insurance Portability and Accountability Act and approved by our institutional review board. In our hospital, it is a common agreement with the transplant surgeons to perform CT-cholangiography instead of MRI for the evaluation of potential liver donors. As reported previously, image quality of intravenous CT-cholangiography is excellent and even better compared to MR-cholangiography in non-dilated biliary systems [5,8]. Consequently, intravenous CT-cholangiography is established in our institutional guidelines for living-related liver transplantation as the method of choice for the preoperative evaluation of the biliary system. All subjects gave written informed consent. Between August 2007 and July 2010, 40 potential donors for living-related liver transplantation underwent preoperative evaluation of the biliary system with intravenous dual-energy CT-cholangiography. Renal insufficiency (creatinine > 1.5 mg/dl), elevated serum bilirubin levels (>1.5 mg/dl), a history of hepatobiliary surgery and adverse reactions to iodinated contrast agents were exclusion criteria. The 40 potential donors were divided equally in two study groups. The control group (CG) consisted of 20 subjects, in which the hepatobiliary contrast agent infusion was combined with an injection of normal saline. The morphine group (MG) consisted of 20 subjects, in which the hepatobiliary contrast agent infusion was combined with an injection of morphine sulfate. Hepatobiliary laboratory data were analyzed and liver volumes were calculated with a manual segmentation technique [19].

2.2. Dual-energy CT-cholangiography

Thirty minutes prior to the contrast agent infusion, all subjects were given premedication with 400 mg cimetidine (Ranitic®, Hexal, Holzkirchen, Germany) and 4 mg clemastinhydrogenfumarat (Tavegil®, Novartis, Munich, Germany) to avoid adverse contrast agent reactions [3]. The hepatobiliary contrast agent, 100 ml of meglumine iotroxate (Biliscopin®, Bayer Schering, Berlin, Germany) was intravenously infused continuously over a period of 40 min [20]. Twenty minutes after the beginning of the contrast agent infusion, either normal saline (10 ml) in the CG or morphine sulfate (0.04 mg per kilogram of body weight; Morphin Hexal®, Salutas Pharma GmbH, Barleben, Germany) in the MG was slowly injected. Forty-five minutes after initiation of the contrast agent infusion, a dual-energy CT acquisition of the liver was performed [13,21]. The examinations were performed with a 64-slice multi-detector dual-source CT scanner (Somatom Definition DS, Siemens Medical Solutions, Forchheim, Germany) [9]. All subjects were positioned slightly eccentrically in the CT gantry to center the liver in the smaller field-of-view of the second detector [22]. The dual-energy CT acquisition provided two simultaneously acquired raw datasets: one at a tube potential of 140 kV with a quality reference of 96 mAs and one at a tube potential of 80 kV with a