Supplementary Material 1. Acquisition of Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) Images

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All patients underwent magnetic resonance imaging (MRI) examinations using a 1.5T (MAGNETOM Avanto, Siemens Healthineers, Erlangen, Germany) or 3T (Achieva, Philips Healthcare, Best, The Netherlands) scanner with a 6- or 16-element phased-array torso coil as the receiver. Fat-suppressed 3-dimensional (3D) spoiled gradient-echo T1-weighted sequence was performed before and after administration of gadoxetic acid (Primovist, Bayer AG, Berlin, Germany), with the following parameters: repetition time (TR)/echo time (TE), 4/1.5 ms; flip angle (FA), 10°; field of view (FOV), 370 x 240–280 mm²; matrix, 320 x 168; parallel factor, 2; and slice thickness (ST), 4 mm for the 1.5T scanner; and TR/TE, 3.3/1.6 ms; FA, 10°; FOV, 340 x 240–280 mm²; matrix, 296 x 227; parallel factor, 2; and ST, 4 mm for the 3T scanner. After intravenous injection of 0.1 mL/kg body weight of gadoxetic acid at 1 mL/s followed by a 20-mL saline flush, the following four phase images were obtained: the arterial phase (determined using a test-bolus method), portal venous phase (25 seconds after completion of the arterial phase images, approximately 50–70 seconds after contrast injection), transitional phase (approximately 3 minutes after contrast agent injection), and hepatobiliary phase images (20 minutes after contrast injection). Subtraction images were automatically generated after the image acquisition using a vendor-provided software (Inline Liver Registration, Siemens Healthineers). Other MRI sequences included axial dual-echo T1-weighted breath-hold gradient-echo sequence (TR/TE, 160/4.9 ms [in-phase] or 160/2.2 ms [opposed-phase]; FA, 70°; FOV, 370 x 240–280 mm²; matrix, 256 x 173; parallel factor, 2; and ST, 6 mm), respiratory-triggered turbo-spin echo T2-weighted sequence with fat saturation (TR/TE, 1900/88 ms; FA, 150°; FOV, 370 x 240–280 mm²; matrix, 384 x 207; parallel factor, 2; and ST, 6 mm), half-Fourier acquisition single-shot turbo-spin echo (HASTE) T2-weighted sequence with fat saturation (TR/TE, 1000/154 ms; FA, 160°; FOV, 370 x 240–280 mm²; matrix, 320 x 144; parallel factor, 2; and ST, 6 mm), and diffusion-weighted imaging (DWI) using a respiratory-triggered single-shot echo-planar imaging sequence (TR/TE, 2000/81 ms; FA, 90°; FOV, 370 x 240–280 mm²; matrix, 192 x 156; parallel factor, 2; and ST, 6 mm) with b values of 0, 50, 500, and 900 s/mm².

Computed tomography (CT) examinations were performed by using 16–detector row CT systems (LightSpeed 16, GE Healthcare, Milwaukee, WI, USA; Somatom Sensation 16, Siemens Healthineers). Unenhanced and triphasic dynamic contrast-enhanced imaging were performed after intravenous injection of 120–150 mL iopromide (Ultravist 370, Bayer AG) at a rate of 3 mL/sec. Scans were initiated 25 seconds after enhancement of the descending aorta to 100 Hounsfield unit (HU) (arterial phase), as measured by using bolus-tracking methods, and 70 seconds (portal venous phase), and 3 minutes (delayed phase) after contrast agent injection. The imaging parameters consisted of beam collimation of 16 x 0.75 mm, beam pitch of 1, gantry rotation time of 0.5 second, 120 kV, and 95–190 mAs with automated dose modulation (CARE dose 4D, Siemens Healthineers) for the Siemens scanner and beam collimation of 16 x 1.25 mm, beam pitch of 0.938, gantry rotation time of 0.6 second, 120 kV, 107–204 mAs with automated dose modulation (AutomA, GE Healthcare) for the GE scanner. The images were reconstructed in the axial plane with 5-mm-thick sections and a 5-mm reconstruction interval.

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MRI was performed using a 3T unit (MAGNETOM Trio A Tim System, Siemens Healthineers) with a combination of a body matrix coil and a spinal matrix coil. Axial images were acquired with the following parameters: fat-suppressed respiratory-triggered T2-weighted turbo spin-echo sequence (TR/TE, 3500–5000/70–85 ms; echo-train length, 10; FA, 140°; matrix, 202 x 320; and ST, 3 mm), breath-hold T2-weighted turbo spin-echo sequence (TR/TE, 2500–4500/103 ms; FA, 140°; matrix, 202 x 320; and ST, 5 mm), T2-weighted HASTE sequence (TR/TE, 400–500/100–150 ms; FA, 150°; matrix, 166 x 256; and ST, 3 mm), and breath-hold T1-weighted fast low-angle shot sequence (TR/TE, 172/2.5 ms [in-phase] or 172/1.2 ms [out-of-phase]; FA, 65°; matrix, 208 x 256; and ST, 5 mm). Dynamic volumetric interpolated breath-hold examination (Vibe, Siemens Healthineers) was performed after intravenous injection of 0.1 mL/kg of gadoxetic acid–based contrast medium (Primovist) at a rate of 1 mL/s and flushed with 25-mL saline. The arterial dominant phase was acquired using
the bolus-tracking method. The portal venous, transitional, and hepatobiliary phases were also acquired at 60–70 seconds, 2 minutes, and 20 minutes, respectively, from the start of contrast injection. Subtraction images were automatically generated after the image acquisition using a vendor-provided software (Inline Liver Registration). During the interval between the dynamic and hepatobiliary phase imaging, diffusion weighted images (TR/TE, 1500/70 ms; FA, 90°; matrix, 192 x 108; ST/gap, 5/1 mm; b-value of 50, 400, and 800 s/mm²) were also obtained.

Dynamic liver CT was performed using a 16-slice multidetector CT scanner (Somatom Sensation 16). The scanning parameters were as follows: 80 kVp, 280 mAs (tube current, 336 mA), detector configuration of 16 x 0.625, 5-mm ST with no gap, gantry rotation time of 0.5 second, single breath-hold helical acquisition of 12–18 seconds depending on liver size, scan coverage of 190 mm, FOV of 300 x 320 mm², and reconstruction Kernel of B30f. After acquisition of the unenhanced phase liver images, the scanning delay for late arterial phase imaging was determined using an automatic bolus tracking technique. The single level monitoring scan (80 kVp, 100 mAs) was initiated 10 seconds after contrast injection. Arterial phase scanning was automatically performed 12 seconds after the trigger attenuation threshold (100 HU) was achieved at the level of the supraceliac abdominal aorta. Fixed time delays were 70 seconds for the hepatic venous (portal) and 180 seconds for the equilibrium phase. The volume of contrast medium delivered varied depending on the body weight of each patient (2 mL/kg of body weight); therefore, the total volume of contrast medium administered was 94 to 150 mL. All patients received a non-ionic iodinated contrast agent (Ultravist 370) at a rate of 3–4 mL/s.

Samsung Medical Center, Sungkyunkwan University School of Medicine

MRI was performed using a 3T MRI system (Intera Achieva, Philips Healthcare) with a 6- or 16-channel phased-array coil as the receiver coil. The MRI protocol included respiration-triggered T1-weighted turbo field-echo in-phase (TR/TE, 3500/2.3 ms; FA, 15°; matrix, 288 x 230) and out-of-phase sequences (TR/TE, 3500/3.45 ms; FA, 90°; matrix, 320 x 256), a breath-hold multishot T2-weighted sequence with a reduction factor of 2 or 4 (TR/TE, 1342/80 ms; FA, 90°; matrix, 320 x 256), and a 1- to 2-mm intersection gap, and a FOV of 32–38 cm. Unenhanced and gadoxetic acid-enhanced arterial phase (20–35 seconds after contrast injection), portal venous phase (60–70 seconds), transitional phase (3 minutes) and hepatobiliary phase (20 minutes) were acquired using a T1-weighted 3D turbo-field-echo sequence (TR/TE, 3100/1.5 ms; FA, 10°; matrix, 256 x 256; ST, 2 mm, with no gap). Gadoxetic acid disodium (Primovist) was administered intravenously at a dose of 0.025 mmol/kg (0.1 mL/kg body weight) at a rate of 2 mL/s, followed by 20-mL saline flush. Subtraction images were automatically generated after the image acquisition. DWI was obtained using single-shot echo-planar imaging with respiratory triggering (TR/TE, 1600/70 ms; FA, 90°; matrix, 112 x 112; ST, 5 mm), with b values of 0, 100, and 800 s/mm² used.

Contrast-enhanced triple-phase helical CT was performed with 16-, 40-, or 64-slice scanners (LightSpeed 16; Brilliance 40, Philips Healthcare; Aquilion 64, Toshiba Medical Systems, Tokyo, Japan). The scanning parameters were 120 kVp, 189–200 mAs, 5-mm ST with an increment (overlap) of 2.5 mm, table speed of 18.75–26.75 mm/rotation (pitch, 0.828–1.07), and a single-breath-hold helical acquisition of 5–8 seconds depending on liver size. The images were obtained in the cranio-caudal direction. Hepatic arterial phase scanning began 30–40 seconds after injection of 120 mL of a nonionic iodinated contrast agent (iopamidol; Iopamiro 300, Bracco, Milan, Italy) at a rate of 3–4 mL/s with a bolus-triggered technique (120 kVp; 40–60 mA; monitoring frequency from 12 seconds after the contrast injection, 1 second; trigger threshold, 100 HU in descending aorta; delay from trigger to initiation of scan, 18 seconds). The contrast agent was administered through the antecubital vein with a power injector. The portal and equilibrium phases of scanning began 70 seconds and 180 seconds after injection of the contrast agent.

Severance Hospital, Yonsei University College of Medicine

All MRI scans were performed using 1.5T or 3T MRI scanners: Magnetom Trio Tim (Siemens Healthineers), Intera Achieva or Ingenia (Philips Healthcare), and Discovery MR750 (GE Healthcare). All images were obtained in the transverse plane with FOV of 44 x 30–33 cm according to the patient’s body size. After localizer images were obtained, two-dimensional
dual-echo T1-weighted gradient-recalled echo images were obtained, with a ST, intersection gap, and TR of 7 mm, 0.7 mm, and 150–192 ms, respectively. The TEs for in-phase and opposed-phase images were 2.3–2.5 ms and 1.1–1.2 ms, respectively. Pre- and post-contrast dynamic images were obtained using a 3D gradient echo sequence with a ST, TR, and TE of 2–4 mm, 2.5–4.5 ms, and 0.9–2.2 ms, respectively. For dynamic imaging, a fixed dose of 9 mL of gadoxetic acid disodium (Primovist) was injected, followed by 20 mL of 0.9% saline at an injection rate of 1 or 2 mL/s. The arterial phase began 3–5 seconds after peak contrast-enhancement of the abdominal aorta. The time-to-peak aorta enhancement was measured using a test bolus technique with 1 mL of gadoxetic acid or by obtaining bolus-tracking images. After arterial phase imaging, three subsequent dynamic phases were obtained: portal, late portal, and transitional phases. Each dynamic phase was obtained in a breath hold, with a scan time of 18–24 seconds. Between each phase, the patients were asked to take one or two breaths. The start times for scanning the arterial, portal, late portal, and transitional phases were approximately 30, 60–70, 90–110, and 130–150 seconds after contrast injection, respectively. Hepatobiliary phase images were obtained at a fixed time delay of 15 minutes after contrast injection using the same imaging sequence that was used for dynamic imaging. Subtraction images were automatically generated after the image acquisition. Between the transitional and hepatobiliary phases, we obtained T2-weighted images with multi-shot and single-shot turbo spin echo sequences using a navigator-triggered technique with a ST, gap, TR, and TE of 5–7 mm, 1 mm, 1589–3250 ms, and 70–96 ms, respectively, and also breath-hold heavily T2-weighted HASTE images with a TE of 150 ms, matrix of 320 x 179, 4-mm ST, 1-mm gap. DWI was also acquired using a navigator-triggered technique at b-values of 50, 400, and 800 s/mm².

Four-phase dynamic CT images were obtained using a 16- or 64-channel multidetector CT scanner (Somatom Sensation 16, Sensation 64, and Definition flash, Siemens Healthineers; Lightspeed VCT, GE Healthcare). The routine four-phase dynamic liver CT protocol at our institution includes nonenhanced, late arterial, portal venous, and delayed phases. After precontrast scanning, patients received an intravenous injection of 2.0 mL/kg of iodinated contrast medium (iopamidol; Iopamiro 300), followed by a 20-mL saline bolus at a fixed injection duration of 30 seconds. Using the bolus-tracking method, late arterial phase images were acquired 18 seconds after the attenuation value reached 100 HU in the abdominal aorta. The portal venous and delayed phases began with a delay time of 30 seconds and 150 seconds after the late arterial phase, respectively. The scanning parameters were as follows: 120 kV; 240 mAs; rotation time, 0.5 second; beam pitch, 2; and ST, 3–5 mm.

Bucheon Hospital, Soonchunhyang University College of Medicine

All MRI examinations were performed using a 3T system (Signa HDxt, GE Healthcare). The protocol consisted of a breath-hold T2-weighted single-shot fast spin-echo sequence (TR/TE, 1350/48 ms; FOV, 200 x 200 mm²; matrix, 384 x 224; and ST, 5 or 6 mm, with an intersection gap of 1 mm, a respiratory-triggered fat-suppressed T2-weighted fast spin-echo sequence (TR/TE, 10000/71 ms; FOV, 200 x 200 mm²; matrix, 320 x 320; and ST, 5 or 6 mm, with an intersection gap of 1 mm), a breath-hold T1-weighted dual-echo sequence (TR/TE, 4/2.2 [in-phase] or 1.1 [opposed-phase] ms; FOV, 200 x 200 mm²; matrix, 256 x 224; and ST, 2.2 mm, with no intersection gap), respiratory-triggered DWI (TR/TE, 10000/37–59 ms; FOV, 200 x 200 mm²; matrix, 128 x 128; ST, 5 or 6 mm, with an intersection gap of 1 mm; and b values of 0, 50, 400, 800 s/mm²), and dynamic contrast enhanced fat-suppressed 3D T1-weighted sequences using liver acquisition with volume acceleration (TR/TE, 4.4/1.3 ms; FOV, 200 x 200 mm²; matrix, 300 x 200; and ST, 2.2 with no intersection gap). For dynamic imaging, before and after the intravenous administration of gadoxetic acid (Primovist), unenhanced, early arterial phase (10 seconds after contrast injection), late arterial phase (35 seconds), portal venous phase (60 seconds), transitional phase (3 minutes), and hepatobiliary phase (20 minutes) images were obtained. Subtraction images of unenhanced phase from early arterial and late arterial phases were also provided.

Contrast-enhanced triple-phase helical CT was performed with 16-, or two 64-slice scanners (SOMATOM Scope or Definition Flash, Siemens Healthineers; Discovery CT750 HD, GE Healthcare). The scanning parameters were 120 kVp, 110–160 mAs, 5-mm ST with an increment (overlap) of 2.5 mm, table speed of 0.6–0.9 mm/rotation. Arterial phase scanning was automatically performed 20 seconds after the trigger attenuation threshold (100 HU) was achieved at the level of the suprarenal abdominal aorta. Fixed time delays were 90 seconds for the portal and 210 seconds for the equilibrium phase. All patients received 150 mL of a nonionic iodinated contrast agent (Iomeron 350, Bracco) at a rate of 3mL/s through the antecubital vein with a power injector.