

# Adjunctive role of preoperative liver magnetic resonance imaging for potentially resectable pancreatic cancer

Hyoung Woo Kim, MD,<sup>a</sup> Jong-Chan Lee, MD,<sup>a</sup> Kyu-Hyun Paik, MD,<sup>a</sup> Jingu Kang, MD,<sup>a</sup> Young Hoon Kim, MD, PhD,<sup>b</sup> Yoo-Seok Yoon, MD, PhD,<sup>c</sup> Ho-Seong Han, MD, PhD,<sup>c</sup> Jaihwon Kim, MD,<sup>a</sup> and Jin-Hyeok Hwang, MD, PhD,<sup>a</sup> *Seongnam, Korea*

**Background.** The adjunctive role of magnetic resonance imaging of the liver before pancreatic ductal adenocarcinoma has been unclear. We evaluated whether the combination of hepatic magnetic resonance imaging with multidetector computed tomography using a pancreatic protocol (pCT) could help surgeons select appropriate candidates and decrease the risk of early recurrence.

**Methods.** We retrospectively enrolled 167 patients in whom complete resection was achieved without grossly visible residual tumor; 102 patients underwent pCT alone (CT group) and 65 underwent both hepatic magnetic resonance imaging and pCT (magnetic resonance imaging group).

**Results.** By adding hepatic magnetic resonance imaging during preoperative evaluation, hepatic metastases were newly discovered in 3 of 58 patients (5%) without hepatic lesions on pCT and 17 of 53 patients (32%) with indeterminate hepatic lesions on pCT. Patients with borderline resectability, a tumor size > 3 cm, or preoperative carbohydrate antigen 19-9 level > 1,000 U/mL had a greater rate of hepatic metastasis on subsequent hepatic magnetic resonance imaging. Among 167 patients in whom R0/R1 resection was achieved, the median overall survival was 18.2 vs 24.7 months (P = .020) and the disease-free survival was 8.5 vs 10.0 months (P = .016) in the CT and magnetic resonance imaging groups, respectively (median follow-up, 18.3 months). Recurrence developed in 82 (80%) and 43 (66%) patients in the CT and magnetic resonance imaging groups, respectively. The cumulative hepatic recurrence rate was greater in the CT group than in the magnetic resonance imaging group (P < .001).

**Conclusion.** Preoperative hepatic magnetic resonance imaging should be considered in patients with potentially resectable pancreatic ductal adenocarcinoma, especially those with high tumor burden. (Surgery 2017;■:■-■.)

From the Departments of Internal Medicine,<sup>a</sup> Radiology,<sup>b</sup> and Surgery,<sup>c</sup> Seoul National University College of Medicine, Seoul National University Bundang Hospital, Seongnam, Korea

PANCREATIC DUCTAL ADENOCARCINOMA (PDAC) is among the most fatal solid tumors.<sup>1,2</sup> Over 80% of patients with PDAC present with a locally advanced or metastatic disease, and most patients die within 5 years. Although 20% of patients with localized PDAC undergo resection and have a

chance of cure, the 5-year survival rate for these patients is only up to 20%.<sup>3,4</sup> To select the right candidates with potentially resectable disease, it is important to perform accurate preoperative radiologic staging to determine the extent of vascular invasion and distant metastasis.<sup>5-7</sup>

Multidetector computed tomography using a pancreatic protocol (pCT) is the best validated, primary imaging modality for evaluating radiologic staging in patients with PDAC and now has become widely available.<sup>8-10</sup> However, pCT has some limitations for detecting and characterizing small hepatic lesions less than 1 cm in size.<sup>11,12</sup> Hepatic magnetic resonance imaging (MRI) is often used to resolve problems and better characterize indeterminate hepatic lesions that were identified previously on pCT. Furthermore, hepatic MRI can often discriminate between metastatic and nonmetastatic diseases.<sup>13</sup>

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Reprint requests: Jin-Hyeok Hwang, MD, PhD, Department of Internal Medicine, Seoul National University College of Medicine, Seoul National University Bundang Hospital, 82, Gumi-ro 173 Beon-gil, Bundang-gu, Seongnam-si, Gyeonggi-do 1588-3369, Republic of Korea. E-mail: woltoong@snu.ac.kr.

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Thus, the guidelines of the National Comprehensive Cancer Network state that hepatic MRI can be considered in these limited cases.<sup>14</sup> A recent report showed that routine preoperative hepatic MRI and computed tomography (CT) have a low diagnostic yield for hepatic metastasis and are, therefore, unnecessary for staging evaluation in patients newly diagnosed with colorectal cancer.<sup>15</sup> PDAC has an increased risk of hepatic metastasis even after curative resection,<sup>16-19</sup> and hepatic metastasis occurs more often in patients with PDAC than in those with colorectal cancer at initial presentation.<sup>20-22</sup>

Considering the biologic differences between different types of cancer, it is reasonable to hypothesize that the roles of preoperative hepatic MRI would differ for PDAC and colorectal cancer. Thus far, there has been no firm evidence that preoperative hepatic MRI has diagnostic and prognostic benefits compared to pCT alone in patients with potentially resectable PDAC. The current study evaluated whether hepatic MRI in combination with pCT could help surgeons select appropriate candidates for operative intervention and thereby decrease the risk of early hepatic recurrence, ultimately providing greater survival times in patients with resected PDAC.

## METHODS

**Patients.** Between January 2006 and December 2014, 248 consecutive patients diagnosed with potentially resectable PDAC by pCT at Seoul National University Bundang Hospital (Seongnam, Korea) were screened for this study; 20 patients were excluded due to hepatic metastasis confirmed by hepatic MRI and biopsy (Fig 1). After excluding 61 patients due to refusal of operative treatment, use of prior chemotherapy, double primary active cancer, mortality within 1 month after operative resection, or failure of macroscopic complete resection, 167 patients who achieved complete resection (R0/R1) with no grossly visible residual tumor were evaluated retrospectively (CT group, 102 patients who underwent preoperative pCT alone; MRI group, 65 patients who underwent both preoperative hepatic MRI and pCT) (Fig 2). The study protocol was approved by the Institutional Review Board of Seoul National University Bundang Hospital (approval B-1512-326-106).

**pCT and hepatic MRI.** All pCT and hepatic MRI scans were reviewed by a blinded, experienced, board-certified abdominal radiologist (Y.H.K.). The pCT was performed by using 64- or 256-detector-row scanners (Brilliance 64 or

iCT256; Philips Medical Systems, Cleveland, OH). Intravenous, nonionic contrast material (2 mL/kg, iopromide, Ultravist 370; Bayer, Berlin, Germany, or 2 mL/kg, iomeprol, Iomeron 350; Bracco, Milano, Italy) was administered via the antecubital vein by using a power injector at a rate of 3 mL/s. Bolus-tracking software (Brilliance; Philips Medical Systems) was used for the arterial phase to trigger the scanning 20 seconds after aortic enhancement reached a threshold of 200 Hounsfield units. The portal venous phase was obtained 60 seconds after the scanning was triggered.

Hepatic MRI was performed in patients with indeterminate hepatic lesions on preoperative pCT, and liver biopsies were conducted subsequently, if indicated. Some patients without hepatic lesions on pCT underwent hepatic MRI, according to the physician's preference. Hepatic MRI scans were performed using a 1.5- or 3.0-T whole-body magnetic resonance system (Intera Achieva, Achieva Tx, or Ingenia; Philips Healthcare, Best, The Netherlands) with a 16-channel (1.5 T) or 32-channel (3.0 T), phased-array coil as the receiver coil. T1-weighted dual gradient-echo axial images were obtained followed by fat-suppressed T2-weighted and heavily T2-weighted images.

For dynamic enhanced imaging, we obtained unenhanced, arterial-phase (20–35 seconds), portal venous-phase (60 seconds), and late-phase (3 minutes) images using a fat-suppressed, T1-weighted, 3-dimensional, turbo gradient-echo sequence. Gadopentetate dimeglumine (0.1 mmol/kg) was administered intravenously until February 2008, and gadoxetic acid (0.025 mmol/kg) was used since March 2008. Additional hepatobiliary phase images (20 minutes) were acquired with gadoxetic acid. Diffusion-weighted images were also obtained.

**Outcomes.** Primary outcomes were overall survival (OS) and disease-free survival (DFS) in both groups. OS was defined as the time from the date of pancreatic resection to the date of death. DFS was defined as the time from the date of pancreatic resection to the date of the first documentation of recurrence or death, if either event had occurred before the documented radiologic or histologic recurrence. Patients alive without recurrence were censored on the date of the last follow-up. Determining factors for OS, DFS, and the organ-specific cumulative recurrence rate were also evaluated.

**Postoperative management and surveillance.** All patients underwent contrast-enhanced, abdominal-pelvic CT to evaluate postoperative complications within 4 weeks. After wound healing, patients with resected PDAC received adjuvant chemotherapy

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