Abstract

**Purpose.** The authors sought to identify metabolic features of pancreatic carcinoma by *in vivo* proton magnetic resonance (MR) spectroscopy at 3 Tesla.

**Materials and methods.** Forty healthy volunteers and 40 patients with pancreatic carcinoma confirmed by histopathology underwent T2-weighted imaging for localisation of the single voxel. Respiration-triggered 1H MR spectroscopy was used to detect metabolites in normal pancreas and cancerous tissue. All spectral data were processed with SAGE software. Unsuppressed water at 4.7 ppm was used as an internal reference to determine metabolite concentrations. Each ratio among the different peak areas was statistically evaluated between normal pancreas and pancreatic carcinoma.

**Results.** The following five groups of spectra were detected: unsaturated fatty acids (–CH=CH–) at 5.4 ppm; residual water at 4.7 ppm; choline metabolites at 3.2 ppm; unsaturated fatty acids (–CH2–CH=CH–) or a combination of N-acetylaspartate (NAA), N-acetylaspartylglutamate (NAAG), glutamine, glutamate, macromolecules and unsaturated fatty acids (–CH2–CH=CH–) at 2.0 ppm and lipids at 1.3 ppm. Ratio of lipids to unsuppressed water in normal pancreas was statistically greater than that in pancreatic cancer (**p**=0.004). Ratio of choline to unsuppressed water in normal pancreas was statistically greater than that in pancreatic cancer (**p**=0.004).
greater than that in pancreatic cancer \( (p=0.0001) \). Ratio of fatty acids \((-\text{CH}=-\text{CH}^-)\) to lipids in normal pancreas was statistically lower than that in pancreatic cancer \( (p=0.006) \).

**Conclusions.** Compared with normal pancreas, pancreatic carcinoma has a higher ratio of fatty acids \((-\text{CH}=-\text{CH}^-)\) to lipids and lower ratios of lipids to unsuppressed water and choline to unsuppressed water at 3T.

**Keywords** Pancreas · Carcinoma · Magnetic Resonance · Spectroscopy · 3T

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**Introduction**

Pancreatic ductal adenocarcinoma is a lethal disease with a dismal prognosis. It ranks ninth in the incidence of solid cancers and fourth for cancer-related deaths, with an overall median survival of around 4–6 months [1]. Despite its high rate of recurrences, surgical resection still remains the only and primary curative treatment option in pancreatic cancer. Owing to the lack of specific symptoms and insufficient diagnostic tools, most pancreatic cancers are diagnosed at a late stage and cannot be visualised as easily and early as cancer of hollow organs of the gastrointestinal tract. Although diagnostic pancreatic imaging modalities, such as ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI), have evolved markedly in recent years, most patients still present with a progressive and incurable state of the disease at diagnosis, with the only option being palliative chemotherapy [2]. Furthermore, preoperative imaging diagnosis is often challenging because of some masslike lesions, such as inflammatory mass, focal lipomatosis, pancreatic abscess or other benign abnormalities [3].

In **vivo** MR spectroscopy, a noninvasive technique, has been successfully used to provide a preoperative diagnosis of malignancies, particularly in several organs, including the brain, breast and prostate [4–9]. The elevation of total choline-containing compounds detected by **in vivo** MR spectroscopy has also been recognised and confirmed as the phenotype of metabolisms in these malignant neoplasms [10–18]. Although **in vivo** \(^1\)H-MR spectroscopy of chronic focal pancreatitis showed less lipids than did the spectra of pancreatic carcinoma at 1.5 Tesla, the specific metabolic markers in pancreatic carcinoma were not detected [19].

With the availability of ultra-high-field magnets for whole-body clinical scanning and the increased signal-to-noise ratio (SNR), there is improvement in both imaging and spectral resolution. Kaplan et al. reported that the ratios of concentrations of taurine, lactate and creatine to phosphocreatine in pancreatic tumours were significantly different from those of normal pancreases at a Bruker AM-360 WB spectrometer [20]. Fang et al. [21], using a DRX-500 spectrometer, also found that decreased phosphocholine and glycerophosphocholine could be the metabolite indicators of pancreatic cancer. However, to the best of our knowledge, evaluation of pancreatic cancer with **in vivo** proton MR spectroscopy with a 3-T scanner has not yet been reported.

In this manuscript, we present our initial experience of using \(^1\)H-MR spectroscopy at 3 T in evaluating pancreatic cancer, providing a comparison with normal pancreas, which might be helpful to further investigate early diagnosis, differentiation and treatment monitoring of pancreatic cancer.

**Materials and methods**

The study was approved by our institutional review board; written informed consent was obtained from all participants.

**Patient population**

Between May 2008 and January 2011, 40 patients (24 men and 16 women; mean age 55.8 years; age range 38–66 years) with pancreatic cancer (range of the smallest diameter 2.2–4.3 cm; mean diameter 3.3 cm) in the head of pancreas proved by histopathology after surgery and 40 healthy volunteers (25 men and 15 women; mean age 55.6 years; age range 40–65 years), who had no previous medical history or current morbidity, were included in this prospective study. Thirty-seven healthy volunteers with a small pancreatic head (unsuitable for positioning the single voxel of