Quantitative Magnetic Resonance Elastography of Solid Pancreatic Masses

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Target audience: Physicians and scientists, interested in MRE of the abdomen.

Purpose: Differential diagnosis of solid pancreatic masses remains an important clinical challenge. Histologically, pancreatic ductal adenocarcinoma (PDAC), due to the desmoplastic reaction and build-up of fibrotic tissues, is likely to have higher stiffness compared to normal pancreas and benign tumors.[1] Mass-forming pancreatitis (MFP) is also characterized by fibrosis, but varies in the degree of atrophy of the mass and adjacent parenchyma.[2] We hypothesized that elastography might be useful in the differentiation of solid pancreatic lesions based on these histological characteristics. Endoscopic ultrasound (EUS) elastography can provide sensitive detection, but it is invasive and sedation is required. MRE is a non-invasive method for visualizing the elastic properties of tissue using phase-contrast MRI techniques which has been shown to provide promising and reproducible stiffness measurements throughout the pancreas at 40 Hz.[3]This study was aimed at evaluating the feasibility of using MRE to differentiate benign from malignant solid pancreatic masses.

Methods: Ten healthy volunteers (5 men, 5 women) and 26 patients (21 men, 5 women) were recruited in this prospective study between Jan. 2014 and July 2014. This study was approved by our Institutional Review Board and written informed consent was obtained from all subjects. The patients had 26 lesions in total, including 8 benign masses [MFP, 7; lipoma, 1] and 18 malignant lesions [PDAC, 16; malignant neuroendocrine tumor, 2]. The diagnosis was confirmed by histopathologic examinations after surgical resection or US-guided biopsy. The mean age was (43.6± 7.1) years [range: (33-58) years] for volunteers and (53.7± 14.2) years [range: (33-73) years] for patients. All examinations were performed on a 3.0T MR scanner (Signa HDX 3.0T system; GE Healthcare, Milwaukee, WI) with an 8-channel, phased-array body coil. Low-amplitude mechanical waves at 40Hz were generated in the upper abdomen using an active acoustic driver located outside the scanner room and a passive drum driver placed on the subject's abdomen. The propagating shear waves were imaged with a multislice EPI MRE pulse sequence to obtain volumetric vector displacement data. The imaging parameters were: TR/TE = 1375/38.8ms; phase offsets = 3; FOV = 40 cm; acquisition matrix = 96×96; number of signal averages = 1; frequency-encoding direction = RL; parallel imaging acceleration factor = 3; number of slices = 32; slice thickness = 3.5 mm. The acquisitions were performed at the end of expiration with five 22-second breath holds and one 11-second breath hold. The elastogram generated using a 3D direct inversion algorithm was used for measuring pancreatic stiffness. The ROIs were oval or irregular and covered most of the lesion in the magnitude images and were then copied to the elastograms for the measurement of the stiffness values in kilopascals.

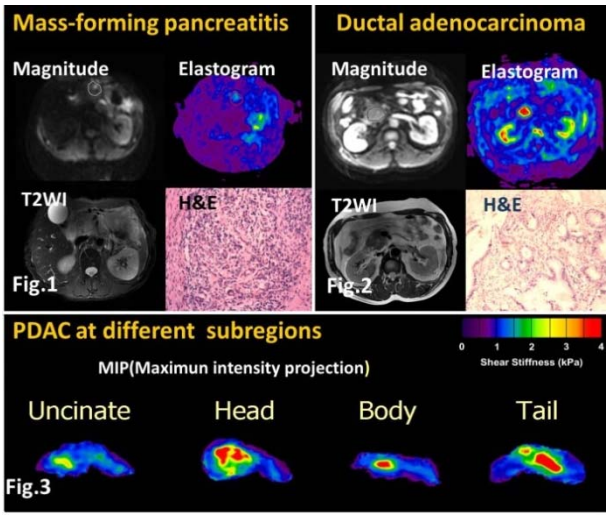

Table 1. Stiffness values in benign and malignant pancreatic tumors

Subjects(36)	Mean size(mm)	Stiffness (kPa)
Lipoma(1)	16	0.78
Normal controls(10)	-	1.12±0.11
MPF(7)	25.1±3.9	1.59±0.31
Malignancy (18)	35.1±12.5	2.70±1.20

Results: As shown in table 1, the mean stiffness of the pancreas in healthy subjects was (1.12±0.11) kPa. Except for the lipoma which had a very low stiffness (0.78 kPa), both MPF [(1.59±0.31) kPa] (Fig.1) and the malignant lesions [(2.70±1.20) kPa] (Fig.2, Fig.3) had higher stiffness than normal pancreas (both $P<0.05$). Malignant lesions had significantly higher stiffness than both MPF and healthy pancreas (both $P<0.01$). MPF showed slightly higher stiffness than healthy pancreas ($P<0.05$), but with overlap over a wide range (1.10-1.92 kPa vs. 0.87-1.49 kPa). Neuroendocrine tumors in 2 cases showed similar stiffness (2.98 kPa, 2.85 kPa) compared with PDAC in 16 cases [(2.63±1.27) kPa].

Discussion:

The present study provides evidence that MRE may serve as a useful tool for the differential diagnosis of solid pancreatic masses. Our results showed that the malignant lesions have much higher stiffness than both MFP and healthy pancreas. Both PDAC (n=16) and neuroendocrine tumors (n=2) had high stiffness. Microscopically, a hallmark in PDAC is the presence of 'desmoplasia', a process in which fibrous tissue infiltrates and envelops neoplasms, which is associated with tumor growth rate and metastasis. The mean collagen content in pancreatic cancer tissue and tumor-associated chronic pancreatitis has been shown to be 3-fold higher than in normal pancreas.[1] Neuroendocrine tumors have been shown to be even stiffer than PDAC based on a previous EUS elastography study.[4] Our two endocrine tumors showed similar stiffness to that of PDAC, but this might be a consequence of the limited number of endocrine lesions in this study. Chronic pancreatitis showed a little higher stiffness than normal pancreas with some overlapping. MFP is also commonly accompanied by fibrosis and calcification, leading to higher stiffness values than healthy pancreas. However, atrophy of the parenchyma with less cellular structure might cause lower stiffness. The final stiffness of MFP is the combination of all these pathological changes, depending on the acute or chronic stage of the disease.[5] In this study, MFP showed lower stiffness than malignant tumors without obvious overlap. Due to the smaller number of subjects with MFP, more experience is needed to generalize the results of the study. Further research is needed to replicate these results in a larger cohort of patients.

Conclusions: Pancreatic MR elastography at 40HZ indicated that malignant tumors have higher stiffness values than those with benign masses and healthy pancreas. This could be helpful in the differentiation of malignancy from benign inflammatory lesions.

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