Pancreatology xxx (2015) 1–4

Contents lists available at ScienceDirect

Pancreatology

journal homepage: www.elsevier.com/locate/pan

Original article

Acoustic radiation force impulse with shear wave speed quantification of pancreatic masses: A prospective study

Mirko D'Onofrio*, Riccardo De Robertis, Stefano Crosara, Cristina Poli, Stefano Canestrini, Emanuele Demozzi, Roberto Pozzi Mucelli

Department of Radiology, G.B. Rossi Hospital, University of Verona, Piazzale L.A. Scuro 10, 37134 Verona, Italy

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Elastography
Pancreatic adenocarcinoma
Pancreatic cystic tumors
Pancreatic cancer
Ultrasonography
Acoustic Radiation Force Impulse (ARFI)

ABSTRACT

Background: Acoustic Radiation Force Impulse (ARFI) is a new ultrasound technique that evaluates mechanical properties of tissues. To evaluate the use of ARFI with shear waves speed quantification for pancreatic masses characterization during the ultrasound examination.
Methods: 123 pancreatic lesions were prospectively evaluated. Median shear waves speeds were compared with Mann–Whitney U test. Two reading methods were applied for the characterization of adenocarcinoma: more than one measurement above the top shear waves speed (SWS) value. Two reading methods were applied to diagnose mucinous lesion: at least 2 (method 1) or 3 (method 2) numerical measurements. Sensitivity, specificity, positive and negative predictive values and accuracy of each reading method were calculated. Forty volunteers were included for normal ARFI values.
Results: In the adenocarcinoma group median SWS value was 2.74 m/s. In the volunteers group the median SWS value was 1.17 m/s. Significant difference between SWS median values of adenocarcinoma and normal pancreas was found ($P < 0.05$). For the diagnosis of pancreatic solid masses if more than one measurement is above the top SWS value of 4.00 m/s results in the study, the diagnosis of ductal adenocarcinoma is highly specific with specificity and PPV of 100%. Good sensitivity (73.3%) and specificity (83.3%) were obtained for the characterization of mucinous cystic lesions.
Conclusions: Acoustic Radiation Force Impulse imaging could help in the non-invasive characterization of solid and cystic lesions of the pancreas during a conventional US examination.

Introduction

Acoustic Radiation Force Impulse (ARFI) imaging is a new ultrasound (US) technique that can evaluate elastic properties of tissues by measuring the propagation speed of shear waves [1–3]. Short-duration (less than 1 ms) acoustic radiation forces produce focal displacements in a region of interest (ROI) [3–5]; using these acoustic push pulses to generate shear waves, ARFI can provide both a qualitative and a quantitative evaluation [6,7]. Tissues' response is related to their viscoelastic properties [3–5]. Particularly, the physical deformation of tissues is related to the resistance to wave propagation [8–13]: the more elastic is a tissue, the slower the shear waves speed (SWS) will be. ARFI has the advantage of being integrated into conventional US equipments and therefore can be performed during a standard examination [14]. Given that US is often the noninvasive imaging modality chosen for the first evaluation of pancreatic diseases, especially in European and Asian countries [15], the more precise and accurate is the initial evaluation, the more adequate the patient management will be. In the last decades, technical advancements as tissue harmonics and contrast medium administration have dramatically improved the image quality and the diagnostic capabilities of conventional US [16–18]. Ductal adenocarcinoma is the most common primary malignancy of the pancreas, thus every pancreatic solid mass detected at US has a very high probability of being an adenocarcinoma, although obviously not all the solid pancreatic masses detected at US are adenocarcinomas; regarding cystic pancreatic lesions, their behavior ranges from benign to frankly malignant [19]. For these reasons, every improvement of the US capability of the first line characterization of pancreatic lesions will lead to both a faster diagnosis and a more accurate differential diagnosis.

* Corresponding author. Tel.: +39 045 8124301, +39 338 2247568; fax: +39 045 8027490.
E-mail address: mirko.donforio@univr.it (M. D'Onofrio).

http://dx.doi.org/10.1016/j.pan.2015.12.003

The aim of this study is to evaluate the efficacy of ARFI imaging with Virtual Touch Tissue Quantification in characterizing solid and cystic pancreatic lesions, comparing the results with those obtained with pathological analysis or with imaging follow-up.

Materials and methods

Patients and lesions

One hundred and fifty patients were prospectively and consecutively enrolled in this study between March 2010 and May 2013.

Inclusion criteria were: presence of focal solid or cystic pancreatic lesion, well evaluable at trans-abdominal US, with a diameter greater than 1 cm. Before ARFI assessment, all solid lesions were evaluated by means of contrast-enhanced ultrasound (CEUS) and a quadriphasic computed tomography (CT) to obtain a radiologic characterization and to stage the disease. After ARFI evaluation, resectable lesions then underwent surgery, while non-resectable or metastatic lesions or doubtful cases underwent ultrasound-guided fine needle aspiration (US-FNA). Regarding cystic lesions, they were first evaluated by means of CEUS and magnetic resonance (MRI) or echoendoscopy (EUS): malignant or potentially malignant resectable lesions (i.e., mucinous cystic neoplasms – MCNs, main duct and mixed type intraductal papillary mucinous neoplasms – IPMNs) were then referred to surgery, while benign lesions (i.e., serous cystadenomas, pseudocysts, and branch-duct IPMNs) were followed with MRI.

CEUS was performed with a Sequoia 512 equipment (Acuson, Mountain View, CA, USA), using 2.4 ml of US contrast medium (Sonovue, Bracco, Milan, Italy). CT was performed with a multidetector scanner (Brilliance 64, Philips, Eindhoven, The Netherlands), using 1.5 ml/kg of iodine contrast medium (Ultravist 370, Bayer Schering Pharma AG, Berlin, Germany). Magnetic resonance imaging was performed with a 1.5 T equipment (Magnetom Symphony, Siemens, Erlangen, Germany) using T1-weighted in- and out-phase gradient recalled echo (GRE) sequences, T2-weighted turbo spin-echo (TSE) sequences, T1-weighted GRE sequences with fat saturation, T2-weighted half-Fourier single-shot turbo spin echo (HASTE) sequences, T2-weighted HASTE MRCP and 3D MRCP sequences, and a dynamic quadriphasic study using T1-weighted volumetric GRE sequences with selective fat saturation (volume interpolated breath-hold examination, VIBE) before and after the administration of 0.2 ml/kg of gadolinium chelates (Multihance, Bracco, Milan, Italy). Echoendoscopy was performed with a linear echoendoscope (Pentax Medical, Tokyo, Japan).

Moreover forty volunteers were used as reference of normal ARFI study.

ARFI evaluation

All patients were examined with ARFI using an ACUSON S2000 equipment (Siemens, Erlangen, Germany), with a 4C1 or a 6C1HD convex probe, using harmonic imaging (THI; 4 MHz) and a mechanical index of 1.7. After the identification of the lesion at conventional B-mode examination, the evaluation with Virtual Touch Tissue Quantification was performed: a fixed size ROI (10 × 5 mm) was positioned within the lesion; 5 measurements were performed on different areas of the lesions during breath hold. The radiologist who performed ARFI was blinded to previous imaging findings. In the volunteers group the ARFI examination were simple performed with two measurements in the head and in the body.

Data analysis

SWS values are expressed as meters per second (m/s) and presented as medians (Interquartile Range – IQR). Median SWS values were compared among groups (adenocarcinomas versus non-adenocarcinomas, serous lesions versus non serous lesions, solid tumors versus normal pancreas) with Mann–Whitney U test; $P < 0.05$ was considered statistically significant. Statistical comparison was performed using IBM SPSS Statistics, Version 20 (IBM Corp, Armonk, NY, USA).

The aim of the evaluation of solid lesions was to characterize ductal adenocarcinoma in respect to normal pancreas and other solid lesions. Moreover the median ARFI value of pancreatic tumor were compared with that of normal pancreas measured in volunteers group. For statistical analysis of solid lesions we calculated the number of lesions with more than one measurement above the top SWS value possible. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy for these two methods were then calculated.

The evaluation of cystic lesions aimed to differentiate serous lesions (benign) from non-serous lesions (malignant or potentially malignant). As the ARFI non-numerical value XXXX/0 is typical of simple fluids as water or serum [18,20], we applied two different measurement methods in order to identify viscous fluid content (mucin): presence of at least 2 (method 1) and at least 3 numerical results (i.e., prevalence of numerical results – method 2).

Results

Patients and lesions

Twenty-seven patients were excluded from this study for the absence of final histological diagnosis (18/27), for the impossibility of performing reliable ARFI measurements for the depth of the lesion (6/27; 4 lesion in the tail of the pancreas and 2 in the head of the pancreas), for the final diagnosis of an extra-pancreatic location of the lesion at surgical resection (namely, 1 duodenal adenocarcinoma and 1 choledocolitiasis) and for the final diagnosis of a pseudocyst, due its extremely heterogeneous content.

The present study therefore included 123 patients (52 males, 71 females, mean age 63 years, range 24–87 years), 69 (55,6%) with a solid pancreatic lesion (62 ductal adenocarcinomas; 3 neuroendocrine tumors, 2 focal fibrosis, 1 acinar cell carcinoma, 1 intrapancreatic common bile duct adenocarcinoma) and 54 (44,4%) with a cystic pancreatic lesion (24 serous cystadenomas, 15 mucinous cystic neoplasms; 15 intraductal papillary mucinous neoplasms).

74 lesions were located in the pancreatic head, 42 in the pancreatic body and 7 in the pancreatic tail.

Five measurements for each lesion were performed with Virtual Touch Tissue Quantification, for a total of 615 measurements.

Forty volunteers were included for normal values comparison.

Measurements

SWS values obtained with ARFI quantification are shown in Table 1. Pancreatic solid masses median SWS value resulted to be 2.78 m/s.

In the volunteers group four measurements were performed in each person, two in the head and two in the body of the pancreas, with a total of 160 values. The median SWS value resulted to be 1.17 m/s (range Q1–Q3: 0.90–1.44). We found significant difference between SWS median values of ductal adenocarcinoma and normal pancreas of the volunteers group ($P < 0.05$).

Please cite this article in press as: D'Onofrio M, et al., Acoustic radiation force impulse with shear wave speed quantification of pancreatic masses: A prospective study, Pancreatology (2015), http://dx.doi.org/10.1016/j.pan.2015.12.003