Neural network analysis of dynamic sequences of EUS elastography used for the differential diagnosis of chronic pancreatitis and pancreatic cancer

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Background: EUS elastography is a newly developed imaging procedure that characterizes the differences of hardness and strain between diseased and normal tissue.

Objective: To assess the accuracy of real-time EUS elastography in pancreatic lesions.

Design: Cross-sectional feasibility study.

Patients: The study group included, in total, 68 patients with normal pancreas (N = 22), chronic pancreatitis (N = 11), pancreatic adenocarcinoma (N = 32), and pancreatic neuroendocrine tumors (N = 3). A subgroup analysis of 43 cases with focal pancreatic masses was also performed.

Interventions: A postprocessing software analysis was used to examine the EUS elastography movies by calculating hue histograms of each individual image, data that were further subjected to an extended neural network analysis to differentiate benign from malignant patterns.

Main Outcome Measurements: To differentiate normal pancreas, chronic pancreatitis, pancreatic cancer, and neuroendocrine tumors.

Results: Based on a cutoff of 175 for the mean hue histogram values recorded on the region of interest, the sensitivity, specificity, and accuracy of differentiation of benign and malignant masses were 91.4%, 87.9%, and 89.7%, respectively. The positive and negative predictive values were 88.9% and 90.6%, respectively. Multilayer perceptron neural networks with both one and two hidden layers of neurons (3-layer perceptron and 4-layer perceptron) were trained to learn how to classify cases as benign or malignant, and yielded an excellent testing performance of 95% on average, together with a high training performance that equaled 97% on average.

Limitation: A lack of the surgical standard in all cases.

Conclusions: EUS elastography is a promising method that allows characterization and differentiation of normal pancreas, chronic pancreatitis, and pancreatic cancer. The currently developed methodology, based on artificial neural network processing of EUS elastography digitalized movies, enabled an optimal prediction of the types of pancreatic lesions. Future multicentric, randomized studies with adequate power will have to establish the clinical impact of this procedure for the differential diagnosis of focal pancreatic masses. (Gastrointest Endosc 2008;68:1086-94.)

Abbreviations: EUS-FNA, EUS-guided FNA; MLP, multilayer perceptron; NN, neural network; NPV, negative predictive value; PPV, positive predictive value; ROC, receiver operating characteristic; SD, standard deviation.

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EUS elastography is a newly developed imaging procedure that characterizes the differences of hardness and strain between diseased tissue and normal tissue. The elastography information is displayed in real time as a transparent color overlay in a defined region of interest, similar to color Doppler examinations.[1-3] EUS elastography was already used in several studies for the characterization and

differentiation of benign and malignant lymph nodes, with variable sensitivity, specificity, and accuracy, better than results obtained by conventional EUS criteria.[2,3] A certain number of pitfalls, however, were reported in these initial investigations, including possible perception errors and motion artifacts, as well as the impossibility of controlling tissue compression.[4] Because of the inherent bias induced by selection of images from a dynamic sequence of EUS elastography, we previously reported on the utility of using computer-aided diagnosis by averaging images from a dynamic sequence and calculating hue histograms, as a better way to describe, semiquantitatively, EUS elastography movies.[5]

EUS-guided tissue sampling methods (EUS-guided FNA [EUS-FNA] and EUS-guided trucut biopsy) have slowly become the procedures of choice used to obtain tissue diagnosis and confirmation of malignancy in focal pancreatic masses.[6-10] However, several recent imaging procedures, including power Doppler EUS, contrast-enhanced EUS, and EUS elastography might challenge conventional EUS as imaging methods that attempt to better describe tissue characteristics, including tissue vascularization and hardness.[11-16] The feasibility of EUS elastography was previously tested in pancreatic diseases, with fair and plausible results.[16,17] The aim of our study was to prospectively assess the accuracy of EUS elastography to differentiate between normal pancreas, chronic pancreatitis, and pancreatic cancer. A postprocessing analysis based on specially designed software was used to analyze the EUS elastography movies by calculating hue histograms of each individual image. Furthermore, an extended neural network (NN) analysis based on mean hue histograms of the EUS elastography movies was tested to differentiate benign versus malignant EUS elastography patterns.

Capsule Summary

What is already known on this topic

- EUS elastography reveals the differences of hardness and strain between diseased and normal tissue, displaying information in real time as a transparent color overlay in a defined region of interest, similar to color Doppler examinations.

What this study adds to our knowledge

- In a study group that included patients with a normal pancreas, chronic pancreatitis, and pancreatic cancer, the sensitivity, specificity, and accuracy of differentiation of benign and malignant masses by using EUS elastography were 91.4%, 87.9%, and 89.7%, respectively; positive and negative predictive values were 88.9% and 90.6%, respectively.

PATIENTS AND METHODS

Patients

The study design was prospective and included a total of 68 patients. The patients were divided in 2 groups consecutively included at the Department of Gastrointestinal Surgery, Gentofte University Hospital, Copenhagen, Denmark (between August 2005 and November 2006), and subsequently at the Department of Gastroenterology, University of Medicine and Pharmacy Craiova, Craiova, Romania (between December 2006 and September 2007). The study prospectively included patients with normal pancreas (N = 22), chronic pancreatitis (N = 11), pancreatic adenocarcinoma (N = 32), and pancreatic neuroendocrine tumors (N = 3) (Table 1). A subgroup analysis was also performed for the patients with focal pancreatic masses, including the patients with pancreatic cancer and the patients with chronic pseudotumoral pancreatitis.

Methods

Two types of analyses were performed by assuming a classification of the results as either ''positive'' (malignant pancreatic focal mass) or ''negative'' (pseudotumoral chronic pancreatitis or normal pancreatic tissue). Initially, a conventional receiver operating characteristic (ROC) analysis was done to compute a cutoff for the differential diagnosis, based on the mean hue histogram values of the EUS elastography individual frames (images), which were averaged for each individual patient movie. Analysis of the EUS elastography movies was based on specially dedicated software developed during a previous study.[5] Furthermore, an extended NN analysis was subsequently performed to improve the accuracy of diagnostic testing. This analysis was again based on the hue histogram values averaged during a 10-second EUS elastography movie. All this information was condensed into an input vector with 256 components for each individual patient and was fed into specific NN software.

Because the concrete database size was not very large (68 cases), the 10-fold cross-validation was used. Accordingly, the classification performance was computed 10 times, each time leaving out one of the subsamples from the computation and using that subsample as a test sample for cross-validation, so that each subsample was used 9 times in the learning stage and just once as the test sample, a complete cycle. To assess the robustness of this method, a complete cycle (ie, 10-fold cross-validation computer run) was run 30 times and provided the average performance values, together with the corresponding standard deviations (SDs).

Protocol of examination

The following data were prospectively collected for all the patients: personal data (name, surname, sex, age, examination date, personal numeric code, diagnosis at admission, and clinical history), conventional EUS

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