

Artificial intelligence in pancreatic cancer: Toward precision diagnosis

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Artificial intelligence (AI) is an emerging concept that refers to computer programs that are able to perform tasks similar to human intelligence, such as learning and problem-solving. Machine learning (ML) involves computer-based methods for data analysis and descriptive or predictive model learning. The concept of deep learning (DL) involves artificial neural networks (ANNs), which are based on the brain's neural structure. Each neuron is a computing unit, and all neurons are interconnected to build a network. In order to train an ANN, the data are divided into a training set used to define the architecture of the network and a test set that evaluates the ANN ability to predict the desired output.

During the past 10 years, important progress has been made on AI use in the medical field, due to its potential for diagnostic and prognostic applications. The mixture of powerful hardware, new techniques, and optimized open-source libraries allows for the development and utilization of very large neural networks in the medical field. The important improvements of DL over other ML techniques have produced a big impact on medical image diagnosis, even

if the transition from methods that use handcrafted features to methods that learn features from the data has been gradual.

One of the most powerful DL techniques is the convolutional neural network (CNN) which could successfully be applied for image registration, anatomical structure detection, image segmentation, and computer-aided disease diagnosis. Among the ML algorithms related to image feature extraction and classification, CNN has been widely proved to be superior to traditional algorithms. These networks provide the flexibility of extracting discriminative features from images preserving the spatial structure and could be developed for region recognition and classification of medical images.

Computer-assisted diagnosis has been used to assist endoscopists in the EUS evaluation of pancreatic lesions with encouraging results. It is well known that, in the presence of chronic pancreatitis (CP), EUS is not always able to differentiate neoplastic from reactive changes. Zhu *et al.*^[1] used computed-aid diagnostic

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techniques to extract EUS image parameters for the differential diagnosis of pancreatic cancer (PC) and CP. Images were obtained from 262 PC and 126 CP patients, and 105 features were extracted. Sixteen of these features were selected for use for classification by a support vector machine, and a sensitivity rate of 94% was obtained. Das *et al.*^[2] applied techniques of image analysis and neural network to develop a model to accurately identify areas of PC on EUS images. The trained ANN model based on digital image analysis of EUS images was very accurate in classifying PC with an area under the curve of 0.93. Ozkan *et al.*^[3] developed an ANN-based approach that analyzed EUS images according to various age ranges. Malignant and nonmalignant EUS images were classified by age as under 40, between 40 and 60, and over 60. According to their results, better diagnostic performances were obtained when age ranges were separately examined.

Our group has also conducted a study to validate the usefulness of an ANN approach to differentiate PC and mass-forming CP based on different quantitative vascularity parameters obtained from postprocessing of contrast-enhanced EUS recordings with a commercially available software.^[4] We were able to show that vascularity parameters can differentiate between PC and CP cases and can be used in an automated computer-aided diagnostic system with good diagnostic results (94.64% sensitivity and 94.44% specificity). Furthermore, we have performed neural network analysis of dynamic sequences of EUS elastography for the differential diagnosis of CP and PC. A postprocessing software analysis was used to examine the EUS elastography movies by calculating hue histograms of each individual image, and data were further subjected to an extended neural network analysis. Multilayer perceptron neural networks (MNNs) with both one and two hidden layers of neurons 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.^[5]

Attempts to integrate computer models into pancreatic cytologic diagnosis have also been reported. One study^[6] used segment images of cell clusters taken from pancreatic fine-needle aspiration (FNA) cytology slides and then trained an MNN to distinguish between benign and malignant cells using extracted features that parallel those used by cytopathologists

in diagnosis. The MNN was at least as accurate as the cytopathologist who originally reviewed the slides. Interestingly, the predictions of the MNN model showed a sensitivity of 80% for inconclusive FNA results. Consequently, this model holds a promising potential to be used as a screening tool for pancreatic FNA specimens. With further improvement, this AI methodology could be used for inconclusive FNA specimens with the potential for an important impact on PC patient care, due to earlier definitive diagnosis and intervention.

AI is also an emerging approach to evaluate the risk of PC. Muhammad *et al.*^[7] reported an ANN that can be used to predict PC, with a sensitivity of 80.7% and a specificity of 80.7%, based only on personal health data. The ANN was also able to stratify people into low, medium, and high cancer risks for more tailored screening and risk management. Computer-aided frameworks could be also implemented as aids for radiologists to identify high-risk pancreatic lesions. For instance, Corral *et al.*^[8] have developed an AI algorithm that can identify pancreatic cysts that are at higher risk of developing into PC.

DL is increasingly used to assist in image analysis for a precision diagnosis, and it also seems particularly valuable to support clinical decision-making in the management of PC patients. Clinical decision-making is becoming more a more complex, given the expanding molecular understanding of the disease, resulting in a data explosion. In such a scenario, DL has an important role by being able to handle large amounts of data. The future direction of research should involve multidisciplinary teams including clinicians and computing and data science professionals to develop AI algorithms to aid the traditional clinical decision-making.

Conflicts of interest

There are no conflicts of interest.

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