Editorial

Endoscopic Ultrasound

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What can artificial intelligence do for EUS?

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INTRODUCTION

Artificial intelligence (AI) is increasingly being integrated into everyday life and swiftly progressing in the healthcare sector. Its benefits are evident in various clinical applications, including diagnosis, personalized treatment guidance, risk assessment, and the reduction of medical errors.[1] Due to the extensive use of endoscopic and radiological imaging, Gastroenterology has evolved into a compelling field for AI applications. Endoscopic ultrasound (EUS) is extensively applied in detecting various gastrointestinal issues, including subepithelial lesions (SEL), early gastric cancer (EGC), and pancreatic diseases. It also allows for solid masses and lymph node sampling. Yoshida et al. used EUS to detect pancreatic lesions and detected a median sensitivity of 93% to 94%, compared to 53% with CT scans and 67% with MRI.[2] However, the accuracy of diagnosis and sampling using EUS is subjective and depends on the endoscopist's skill, experience, and precision.

With the advent of large language models (LLM), machine learning (ML), and deep learning (DL), AI holds the potential to transform patient experiences through improved patient selection, counseling, and education. Furthermore, these novel technologies can enhance the efficiency of EUS by enabling the prediction of patterns and providing more profound insights. In our editorial, we aim to discuss the potential of AI-enhanced EUS as well as the various challenges it faces.

BENEFITS OF USING AI IN EUS

AI can be employed in various facets of EUS, from preoperative counseling to intraoperative and postoperative guidance.

Pre-endoscopy planning

Pre-EUS planning requires automation, accuracy, speed, and privacy but is complicated by patient diversity, multimodal inputs, and imprecise diagnostic criteria. Large Language Models (LLMs) can be utilized to generate and interpret structured data in electronic health records, supporting clinical decision support (CDS) systems that predict EUS outcomes.[3] Additionally, the computational abilities of LLMs can streamline the generation of clinical notes, facilitate the assignment of billing codes, and enable smooth transitions between endoscopists.

LLMs can also analyze unstructured data, such as clinical notes from electronic records and communications, integrating this information with relevant literature to identify patterns and predict potential complications that might be overlooked through traditional methods.[2,4] Moreover, LLMs can potentially create personalized educational materials for patients scheduled for EUS. Various educational chatbots and current-generation LLMs can deliver dynamic, tailored patient education based on an individual's medical history, laboratory, and imaging findings. These tools can also respond to patients' messages, providing an additional resource for endoscopists to save time.[5]

Education

AI can be used to provide training and education to endoscopists. In a study conducted by Zhang et al., a system named BP MASTER (pancreaticobiliary master) was created for this purpose.[6] The classification model played a pivotal role in identifying the current scan site and guiding subsequent operations, and the segmentation model continuously monitored the abdominal aorta, pancreas, and portal. If the critical blood vessels and pancreas were no longer visible, the recommendation was to rescan at the previous station. During internal and external verification, the classification model exhibited accuracies of 94.2% and 82.4%, respectively. In the study, there was a significant improvement in trainees' ability to recognize EUS videos from 67.2% to 78.4% (95% CI, 0.058–1.663; $P < 0.01$).[6]

Similarly, Medranda et al. deemed EUS as a highly skilled procedure with a learning curve and only a limited number of facilities available for such training that requires resources and high patient volume. They also concurred that AI could improve the training process by overcoming the above limitations by recognizing the anatomical landmarks and thus reducing the learning curve. AI added recognition of anatomical structures, which improved the training process.[7] Another model created by Yao et al. achieved an accuracy of 93.3% in the image set and 90.1% in the video set. When compared to a man-machine contest, the AI model was comparable to an expert. On further analysis, with AI trainee's accuracy had improved from 60.8% to 76.3% ($P < 0.01$; 95% CI, 20.9–27.2).[8]

Intraprocedural guidance

AI-enhanced EUS can help improve EUS outcomes by offering intraprocedural guidance requiring precision, real-time guidance, and high resolution. AI can reduce human error by providing consistent readings and highlighting areas of concern that require closer

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examination. AI algorithms can also analyze images much faster than human counterparts, leading to quicker diagnosis and the ability to conduct more examinations in less time. It can integrate EUS data with other medical records to provide a better assessment of a patient's condition, potentially leading to better personalized treatment plans.

AI-guided visualization during EUS

Its integration is being used for the following:

A. Gastrointestinal stromal tumors (GIST): AI-enhanced EUS seems promising for diagnosing SELs with Convoluted Neural Network (CNN)–driven AI models having high sensitivities, specificity and overall accuracy for diagnosing GISTs.[9,10] AI model has been reported to successfully diagnose GIST ≥20 mm and distinguish GIST and non-GIST patients from nongastric SELs. A study based on the DL model reported a sensitivity of 90.5%, specificity of 90.9%, and accuracy of 90.6% in recognizing GIST.[9] A meta-analysis study reported pooled sensitivity and specificity of EUS-AI by CNN in diagnosing GISTs 0.92 (95% CI, 0.89–0.95) and 0.82 (95% CI, 0.75–0.87), respectively. These results were superior to those of endoscopists, and the model was also found to be robust in accurately predicting the malignant potential of GIST.[10]

B. Early gastric cancer (EGC): Accurate preoperative CT scan and EUS are key imaging modalities for staging EGC. The stage of EGC helps to decide whether the patient should undergo endoscopic submucosal dissection *versus* endoscopic mucosal resection and surgery. An AI-based EUS system has been found to be comparable to that of experts in diagnosing invasion depth of EGC.[11] Chen et al. also reported that AI could potentially substitute EUS and CT in staging EGC with an average validation accuracy of 86.1% compared to 70% with EUS and CT scans.[12]

C. Pancreatic diseases: Pancreatic cystic lesions (PCL) of the mucinous type can progress to malignancy. EUS imaging alone is inaccurate in differentiating mucinous from nonmucinous cystic lesions. When an EUS imaging-based Convoluted Neural Network (CNN) model was used to differentiate mucinous and serous cystic neoplasms, it achieved an overall accuracy of 82.7.[13] Another CNN-based high-precision algorithm developed to aim at the automatic identification of mucinous pancreatic cysts achieved a sensitivity and specificity of 98.3% and 98.9% with an overall accuracy of 98.5%.[14] AI models have successfully detected intraductal papillary mucinous neoplasm (IPMN) with an accuracy of 94% compared to 40%–60% by conventional EUS and 56% by endoscopists' diagnosis.[15] CNN/computer-aided diagnosis (CAD) algorithms have enhanced the ability of endoscopic ultrasound–guided needle-based confocal laser endomicroscopy (EUS-nCLE) to differentiate the types of PCL and have been shown to diagnose advanced tumors in IPMN more accurately.[16]

AI-based models have been used for intrapancreatic mucinous neoplasm, with few models reporting a sensitivity of nearly 100%.[14–17] A systematic review looking at the role of EUS-AI for the diagnosis of PC reported overall sensitivity and specificity in the range of 83%–100% and 50%–99%, respectively, with an overall accuracy of 80%–97.5%.[17] Classification and segmentation models can also be used for intraprocedural guidance.

AI-assisted EUS-FNA and FNB

EUS allows rapid on-site evaluation (ROSE) by endoscopic ultrasound-guided fine-needle aspiration (EUS-FNA) and ultrasound-guided fine-needle biopsy (EUS-FNB) to predict and characterize pathology. The accuracy of obtaining samples using EUS-FNA depends on the availability of ROSE as well as the diagnostic experience of the cytopathologists.[18] Using new-generation needles for EUA FNB allows histological examination by preserving tissue structure. AI has the potential to aid in endoscopic ultrasound–guided fine-needle aspiration/biopsy (EUS-FNA/FNB) by offering real-time feedback to endoscopists throughout the procedure. This assistance involves selecting the suitable size as well as the type of puncture needle, directing both the depth and location of the puncture, and also helps in evaluating the sample's quality. Consequently, AI holds promise in reducing the number of punctures needed to acquire a sufficient sample, enhancing puncture precision, and mitigating the risk of complications.[19,20] Thus, AI can potentially be used to guide EUS-FNA/FNB through intraprocedure real-time navigation feedback that can guide selecting the right size and type of puncture needle, location as well as depth of puncture, and quality of sample procured.

AI-assisted cytopathologic diagnosis from EUS-FNB sample

An AI-based approach is being explored to assess specimens from EUS-FNB, leveraging deep and contrastive learning techniques. Ishikawa et al. utilized steromicroscopic images from EUS-FNB specimens using deep learning methods. They reported macroscopic on-site evaluation (MOSE) to have an accuracy of 81.6% when compared to AI-based methods, which achieved an accuracy of 71.8. However, the application of contrastive learning to EUS-FNB specimen after hematoxylin and eosin staining led to an enhanced performance with AI-based diagnostic methods yielding 90.3%, 53.5%, and 84.3% sensitivity, specificity, and accuracy, respectively, compared to 88.9%, 53.5% and 83.4% by MOSE.[21]

Postprocedural applications

LLMs have the potential to generate procedural notes with hyperrealistic images that may save endoscopists time. As with preoperative counseling, LLMs can be utilized for postprocedural instructions, answering patients' questions, reminding them of the next appointment, and patient education. To improve the diagnostic efficiency in pancreatic cancer using EUS-FNA biopsy, a segmentation deep learning–based model called rapid on-site cytopathology evaluation (ROSE) has developed. A DCNN system was created to segment and identify cancer cell clusters from cytopathology slides. Testing across multiple hospitals validated its accuracy, showing an F1 score of 0.929 and an area under the curve (AUC) above 0.900 for cancer detection. The system's performance was comparable to that of cytopathologists, demonstrating its potential clinical utility.[18]

Challenges and limitations with AI in EUS

AI-enhanced endoscopic ultrasound (EUS) offers diagnostic capabilities and accuracy comparable to or surpassing those of endoscopists. This is primarily due to AI's independence from factors like experience, knowledge reserves, training background, inattention, fatigue, and subjectivity. AI-enhanced EUS-FNA/FNB holds promise by enabling precise localization and reducing the required punctures to obtain samples. Additionally, EUS-AI segmentation and classification models facilitate real-time navigation and quality control, helping to identify any missed pathology in blind spots.

However, while the field of AI in medicine is evolving and exciting, it is essential to acknowledge its limitations. The reproducibility of

AI models continues to remain uncertain at this stage. AI's application in EUS is still in its early stages of development and needs more massive and high-quality data to develop high-accuracy machine learning models.[22] Gathering such a high volume of data can be not only difficult but also expensive. Another issue that is faced with AI is overfitting, which develops from a low-volume dataset. This impairs generalization and affects the overall results.[22] Bias can also develop if the dataset is not representative of the intended population. To mitigate these challenges, robust AI models and a variety of datasets are required. Additionally, we need more prospective studies and studies to further test real-world applications prior to integration into clinical practice.[22] Additionally, there is always a risk of misdiagnosis as we still do not fully understand the reason behind the decisions made by AI.[23] This could be mitigated by conducting quality assessments prior to using these models in clinical practice and avoiding being overly dependent on AI.

Other factors that limit the development of AI includes using of graphic processing unit for algorithm's operation, which has limited storage capacity and makes it difficult for using all of the information in images; and lack of standardization of input data, which is used to train AI models.[23] Standardization of data includes the uniformity in collecting, processing, storing, reproducing, and analyzing the data. There is also limitation in AI trained in a specific environment to produce similar results in different environments or devices, which contributes to lack of standardization. Additional factors affecting the standardization include staining quality interference due to difference in smear thickness, distribution, concentration, and observation based on cytotechnologists. This can be improved by ensuring that the cells are fully coated with dye and the stain is timely dried.[23]

Use of AI in guiding puncture sites during EUS/FNA has several limitations and shortcomings, with most important being the challenge in dynamic image recognition as EUS images are influenced by external elements like patient's heartbeat or breathing. There needs to be an addition of real-time corrections to compensate for these discrepancies.

Despite the apprehensions, AI appears to be a permanent fixture, and the medical community must harness its potential to assist in managing physicians' increasing workloads, ensuring that it remains a helpful tool rather than becoming dominant.

Conflict of Interest

Siyu Sun is the Editor-in-Chief of the journal, and Manoop S. Bhutani is an Associate Editor-in-Chief. The article was subjected to the standard procedures of the journal, with a review process independent of the editors and their research group.

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