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Artificial Intelligence in the Early Diagnosis of Inflammatory Bowel Disease: A Valuable Tool That Needs Further Refinement

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Abstract

The early diagnosis of inflammatory bowel disease (IBD) is crucial for improving patient prognosis. However, some patients experience diagnostic delays due to atypical clinical presentations. Current methods widely used in clinical practice may be insufficient for early diagnosis of IBD. Artificial intelligence (AI) technology is gradually being applied to the medical diagnosis of diseases. AI systems can accurately identify intestinal pathologies through advanced image analysis; convolutional neural networks have demonstrated particular efficacy in detecting mucosal erosions and ulcers in both standard and capsule endoscopy images. These systems also enhance radiological assessment by reducing image noise and synthesizing weighted magnetic resonance imaging (MRI) sequences, thereby improving image quality and diagnostic information yield. The combination of AI-assisted endoscopy and medical imaging technology has significantly improved the detection rate of intestinal lesions. Nevertheless, limitations persist as training datasets may contain inherent biases and fail to fully represent clinical diversity. In conclusion, while AI applications show promising potential for early IBD diagnosis, they still need to be improved in the future.

Keywords

Inflammatory Bowel Disease, Early Diagnosis, Artificial Intelligence

1. Introduction

Early diagnosis of inflammatory bowel disease (IBD), particularly Crohn's disease (CD), remains challenging, often leading to delayed diagnosis and treatment initiation [1]. Early diagnosis and timely treatment are important for remission and prognosis of patients with IBD [2] [3]. Diagnostic delays in IBD primarily arise from atypical symptoms and ambiguous clinical or endoscopic presentations. Consequently, meticulous evaluation of mucosal lesions and imaging features has become pivotal for establishing diagnoses during the early disease course.

In recent years, artificial intelligence (AI) has advanced rapidly and is increasingly integrated into medical diagnostics and therapeutic monitoring. AI is capable of quickly processing and accurately analyzing large amounts of medical data. Within gastroenterology, AI technologies are demonstrating promising utility in endoscopic interpretation and imaging-based diagnostic support [4] [5]. These developments suggest that AI holds significant potential to address current limitations in early IBD diagnosis. In this article, the commonly used tests for diagnosing IBD and their limitations are summarized. Despite the advantages of AI technology in this regard, its limitations in the diagnosis of IBD are also discussed.

2. Current Methods for Diagnosis of IBD and Their Limitations

The current diagnosis of IBD relies on a combination of the patient's clinical presentation, laboratory tests, endoscopy, and radiological imaging findings. Based on these results, a determination is made: whether the patient has IBD, and if so, whether it is ulcerative colitis (UC) or CD. The diagnostic methods widely used in clinical practice are summarized in **Table 1**.

Although physicians' experiences may vary and medical facilities may have different resources, all relevant tests should be conducted as promptly as possible to aid in the diagnostic process. Nevertheless, in some cases, the test results may be inconclusive, and the clinical manifestations of UC, CD, and other intestinal inflammatory diseases often overlap, making it challenging for clinicians to reach a definitive diagnosis.

3. AI Assistance in Endoscopic Examination

The AI-assisted image processing system can efficiently and comprehensively analyze numerous endoscopic images, enabling more accurate identification of mucosal inflammation, bleeding locations, and even epithelial cell dysplasia [6] [7]. Dhaliwal *et al.* collected clinical, endoscopic, radiographic, and histological data from 74 patients with colonic IBD. They trained a random forest classifier on a complete dataset and used machine learning to identify histological and endoscopic features that distinguish colonic UC from CD [8].

Convolutional neural networks (CNNs) are a subtype of deep learning systems that can work like the brain nervous system to combine and analyze data to detect intestinal ulcers, erosions, and strictures [9]. In other words, AI can carefully identify and diagnose intestinal pathologies that are not easily detected by humans, thereby providing information to doctors and contributing to the early diagnosis of IBD [10].

Table 1. The methods extensively used in clinical practice for diagnosis of IBD.

Clinical presentation	Laboratory tests	Endoscopy	Medical imaging technology
Abdominal pain	Stool	Colonoscopy	CTE
Diarrhea	CRP	Gastroscopy	MRE
Bloody stool	PCT	Capsule endoscopy	FUGBS
Fever	Blood albumin	Enteroscopy	Barium enema
Anal fistula	White blood cell	Chromoendoscopy	
Others	Fecal calprotectin	NBI	
		Magnifying endoscopy	
		Confocal endoscopy	

CRP: C reactive protein; PCT: Procalcitonin; NBI: Narrow-band imaging; CTE: Computed tomography enterography; MRE: Magnetic resonance enterography; FUGBS: Fluoroscopy of upper gastrointestinal barium swallow.

Capsule endoscopy (CE) plays a crucial role in the detection of small intestinal mucosal lesions. However, the analysis of CE images can be labor-intensive and prone to errors. Therefore, AI-assisted diagnostics offer significant benefits. Current studies demonstrate the application of CNNs for detecting small intestinal mucosal erosions and ulcers in CE imaging data, facilitating early diagnosis of CD [11] [12].

AI can assist in identifying various mucosal morphologies and features in real-time during colonoscopy examinations. It can also help to detect details that doctors might overlook, enabling a more objective assessment of the patient's intestinal mucosal condition. In China, AI is currently recommended to assist throughout the entire colonoscopy procedure, including bowel preparation and lesion characterization [13].

4. AI Assistance in Radiological Image Assessment

Radiography plays a crucial role in the diagnosis of intestinal diseases. Computed tomography (CT) and magnetic resonance imaging (MRI) are extensively used diagnostic modalities in clinical practice for medical imaging. AI technology has significant applications in radiological imaging diagnostics.

AI demonstrates significant potential for image noise reduction, particularly through the application of deep learning algorithms such as residual learning, dense network learning, and batch normalization. These techniques can substantially enhance the signal-to-noise ratio of images. Furthermore, deep neural network technology has been employed to synthesize corresponding artificially weighted images, thereby achieving improved image quality and extracting more valuable information [14].

In addition, radiomics is a novel imaging research method that has been developed in recent years. It enhances clinical diagnosis by extracting additional information from multimodal medical images through advanced feature analysis. With the aid of AI, image segmentation and high-throughput feature extraction are performed on the lesion area, thereby improving the accuracy of lesion identification and assessment. Currently, this approach has been applied in the staging of colorectal tumors [15].

Jeri-McFarlane *et al.* utilized MRI-based visual image reconstruction and CNN algorithms to analyze and diagnose anal fistula lesions in patients with CD [16]. Similarly, Han *et al.* investigated the characteristics of anal fistulas by integrating CT imaging with AI technology [17]. These studies demonstrate that AI offers significant advantages in identifying small intestinal lesions and holds considerable potential for the early imaging diagnosis of CD. In another clinical study, 330 patients with CD or intestinal tuberculosis were enrolled to develop AI models. The study revealed that an arterial-venous combined model, based on deep learning radiomics analysis, exhibited strong performance in differentiating between CD and intestinal tuberculosis [18]. These studies show the advantages of AI.

Therefore, AI in medical image processing has demonstrated broad application prospects and significant potential for development in areas such as noise reduction, lesion segmentation, and quantitative analysis, which could greatly aid in the early diagnosis of IBD.

5. Combination of Endoscopy and Medical Imaging Findings Based on AI Assistance

AI-based imaging analysis can guide the selection of endoscopic biopsy sites. The integration of AI-assisted endoscopy and radiography significantly enhances the detection of intestinal lesions. This approach represents an effective method for the early diagnosis of IBD. Gong *et al.* [19] enrolled 105 patients with CD or intestinal tuberculosis and developed a nomogram integrating clinical factors, endoscopy findings, CTE features, and radiomic scores through multivariate logistic regression analysis. They concluded that the clinical-radiomics model could accurately differentiate CD from intestinal tuberculosis.

Figure 1 shows the benefits of AI assistance in endoscopic and radiological image analyses.

6. Limitations and Challenges of AI Assistance

AI-assisted diagnostic systems rely on datasets that inevitably contain biases and may not fully represent real-world clinical diversity [20]. Systematic errors in AI implementation could potentially compromise diagnostic accuracy and subsequent treatment decisions [21]. Continuous refinement of AI's auxiliary capabilities remains crucial to facilitate their clinical evolution.

In a recent study [22], researchers developed AI algorithms using 1,796 endoscopic images and clinical data from 494 patients to differentiate IBD from both infectious and ischemic colitis. While demonstrating strong concordance with expert endoscopists' diagnoses, the study authors emphasize the necessity for large-scale prospective cohort studies to evaluate clinical efficacy.

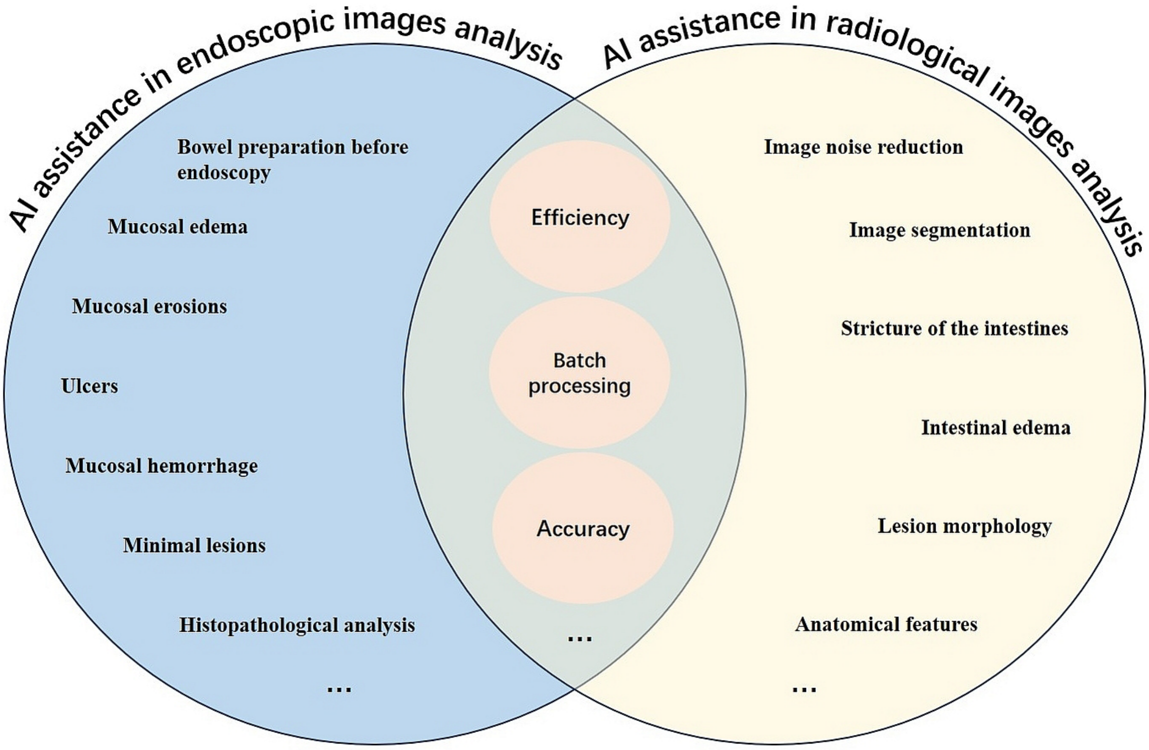

Figure 1. Benefits of AI assistance in endoscopic and radiological image analyses.

As an emerging technology, AI is currently undergoing development and refinement. However, algorithm models associated with endoscopic and histopathological images, as well as other medical imaging modalities, remain insufficiently validated. This immaturity poses risks of system failures and diagnostic errors (including misdiagnosis and missed diagnoses). Consequently, AI-assisted diagnostic outputs still require rigorous validation and oversight by medical experts.

7. Summary

AI is an effective tool for the early diagnosis of IBD. However, there are still some limitations that need to be addressed. In the future, it is essential to further refine and enhance its capabilities and establish comprehensive guidelines for its application in diagnosis, treatment, monitoring, and other related areas. AI holds great promise in this field, and healthcare professionals should strive to master AI technologies to remain relevant and avoid being left behind in the era of AI-driven medicine.

8. Conclusion

AI assistance is a potential and valuable tool for the early diagnosis of IBD, but it needs to be gradually improved worldwide.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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