



Artificial intelligence in gastroenterology: Ethical and diagnostic challenges in clinical practice

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Abstract

This article discusses the manuscript recently published in the *World Journal of Gastroenterology*, which explores the application of deep learning models in decision-making processes *via* wireless capsule endoscopy. Integrating artificial intelligence (AI) into gastrointestinal disease diagnosis represents a transformative step toward precision medicine, enhancing real-time accuracy in detecting multi-category lesions at earlier stages, including small bowel lesions and precancerous polyps, ultimately improving patient outcomes. However, the use of AI in clinical settings raises ethical considerations that extend beyond technological potential. Issues of patient privacy, data security, and potential diagnostic biases require careful attention. AI models must prioritize diverse and representative datasets to mitigate inequities and ensure diagnostic accuracy across populations. Furthermore, balancing AI with clinical expertise is crucial, positioning AI as a supportive tool rather than a replacement for physician judgment. Addressing these ethical challenges will support the responsible deployment of AI, through equitable contribution to patient-centered care.

Key Words: Artificial intelligence; Endoscopy; Ethical implication; Gastrointestinal disease; Machine learning; Omics; Precision medicine; Wireless capsule endoscopy

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Core Tip: Integrating artificial intelligence (AI) in gastrointestinal diagnostics enhances early detection accuracy, offering a promising tool in precision medicine. These models, such as those employed in wireless capsule endoscopy, enable real-time identification of subtle lesions that might be missed by clinicians alone. However, the ethical implications are significant. AI systems must address data security and biases, particularly regarding equitable care across diverse patient groups. Additionally, AI should support rather than overshadow clinical judgment, maintaining the critical balance in physician-patient relationships. By focusing on these ethical pillars, AI's role can evolve responsibly, delivering both innovative and fair diagnostics while safeguarding patient trust.

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TO THE EDITOR

The landscape of diagnostic medicine, particularly in gastroenterology, is rapidly evolving with the integration of artificial intelligence (AI). The capacity of AI and deep learning models to elevate early diagnosis and detection of gastrointestinal (GI) diseases, most notably GI cancers, marks a revolutionary stride toward precision medicine. In the field of diagnostic imaging, AI technologies have proven to be invaluable, enhancing the accuracy of procedures like endoscopy throughout the explorable GI tract[1,2]. These AI-driven advancements facilitate real-time analysis and allow for the identification of early-stage precancerous polyps and subtle lesions that might otherwise escape detection by the human eye.

Recent studies underscore the significant potential of these AI-technologies in gastroenterology. In a retrospective study recently published in the *World Journal of Gastroenterology*, Xiao *et al*[3] proposed a deep learning-based multi-lesion classification model that successfully identified and labeled 23 distinct types of digestive tract lesions *via* wireless capsule endoscopy (WCE). This model not only improves lesion detection rates but also provides a nuanced analysis capable of simultaneously categorizing multiple lesion types. Evaluating the clinical value and developmental potential of this WCE detection model reveals its impact on diagnostic precision and efficiency, leveraging advanced deep learning techniques, such as the Swin Transformer[4], to accurately and rapidly detect a wide variety of lesions. These advancements substantially reduce the manual workload and error rates associated with the high volume of WCE images, marking a pivotal contribution to gastroenterological diagnostics. The authors suggest that future research should focus on expanding the dataset to include rare and complex lesions, potentially using generative adversarial networks to generate supplementary training images, thereby further enhancing the model's robustness. Additionally, optimizing this model for other imaging modalities, including computed tomography scan and magnetic resonance imaging, and enhancing its functionality on resource-limited devices could extend its clinical application well beyond WCE. Such improvements will reinforce the robustness and adaptability of the WCE detection model, offering a foundation for improved diagnostic capabilities across multiple medical domains. These applications hold particular significance in high-stakes procedures, where missed or misidentified lesions could have severe repercussions[5], as early identification and characterization of multi-category lesions empowers clinicians to design personalized treatment strategies, thereby significantly enhancing patient outcomes.

The implications of integrating AI into GI diagnostics extend beyond improved detection; they reshape the entire diagnostic workflow (Figure 1). AI-driven diagnostic tools are already transforming clinical workflows by streamlining the diagnostic process and enabling faster, more accurate analyses. Traditionally, clinicians have spent significant time and resources manually analyzing high-resolution imaging data from procedures like WCE. However, AI-powered models now automate much of this work, reducing the time required to reach a diagnosis and freeing up valuable time for clinicians to focus on treatment planning and patient care[6]. This efficiency is crucial in managing the growing number of GI cases, where a timely diagnosis can significantly influence treatment options and outcomes. However, the integration of these technologies into routine clinical practice necessitates robust validation studies and the development of user-friendly interfaces for healthcare providers.

At present, it is reasonable to anticipate that AI could find applications across various domains of gastroenterology. One of the most compelling applications of AI in GI diagnostics is its capacity for predictive analysis, an innovation that aligns with the core principles of precision medicine. By leveraging large datasets that include imaging data, genetic information, and patient medical histories, AI can assist in predicting disease progression and recurrence risks for conditions like colorectal cancer or inflammatory bowel disease. For instance, an AI model trained to recognize recurrence markers could alert clinicians to the likelihood of cancer relapses, allowing for more proactive and personalized interventions[7]. Similarly, in chronic diseases such as Crohn's disease or ulcerative colitis, AI can aid in anticipating disease flare-ups or predict benefit from biologic therapy, supporting clinicians in devising early and targeted treatment strategies[8,9]. Moreover, algorithm-driven localization in WCE significantly boosts the accuracy of lesion detection after incomplete endoscopic procedure, potentially improving overall completion rates[10]. This predictive capability shifts the focus from reactive to proactive and preventive care, underscoring AI's transformative potential in gastroenterology.

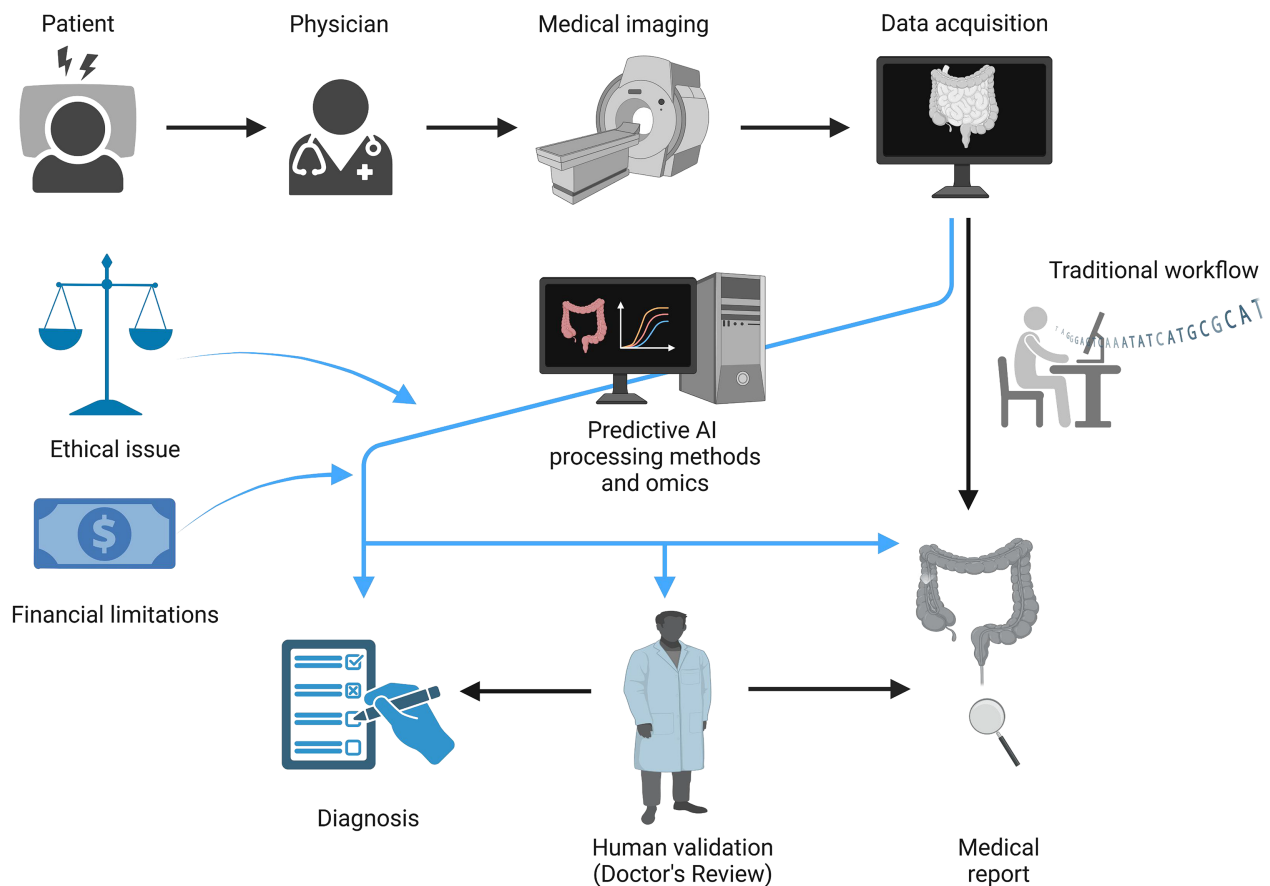


Figure 1 Artificial intelligence diagnostic workflow in gastrointestinal diseases. This workflow illustrates how artificial intelligence can transform gastrointestinal diagnostics by serving as a complementary tool to augment clinical judgment and improve early disease detection. It begins with data collection where medical images, patient histories, omics data and test results are inputted into artificial intelligence (AI) systems. AI then analyzes the data, identifying patterns and potential issues. The results are not final but are reviewed by healthcare professionals, ensuring human expertise validates the AI's findings. This collaborative approach improves diagnostic accuracy while maintaining the personalized care patients need. Ethical considerations, including patient privacy, data security, algorithmic bias, and the transparency of AI decision-making, are integrated into every step of the process. By respecting these principles, AI strengthens the healthcare system, enabling earlier diagnoses without compromising trust or safety. AI: Artificial intelligence.

Other potential application includes the diagnosis of structural and functional disorders, such as hiatal hernia and achalasia. In the case of hiatal hernia, AI algorithms could be applied to imaging data to enable precise assessments of anatomical abnormalities, facilitating early detection and personalized treatment strategies[11]. Similarly, for achalasia, AI-assisted analysis of high-resolution esophageal manometry significantly enhances the classification of motility disorders[12]. Building on this, AI-driven diagnostic systems have also emerged as transformative tools to address the substantial challenges posed by upper GI cancers, which often progress asymptotically in their early stages. As previously mentioned, AI demonstrates exceptional proficiency in analyzing high-resolution endoscopic images, enabling the detection of early neoplastic changes with remarkable sensitivity[13,14]. Therefore, machine learning models trained on extensive datasets of upper GI images have achieved impressive accuracy, contributing to the prediction of postoperative complications and disease progression following upper GI surgeries for malignancies[15].

In addition to these diagnostic advancements, upper GI cancers often lead to nutritional complications, such as progressive dysphagia and cachexia. AI-based predictive models can assess malnutrition risk and provide personalized nutritional intervention recommendations[16,17]. By addressing both diagnostic and supportive care needs, AI offers a comprehensive approach to managing upper GI cancers, with the potential to enhance clinical outcomes and improve patient quality of life.

DISCUSSION

Advances in diagnosis: Omics and AI integration

The integration of omics sciences and AI is reshaping the landscape of biomedical research and clinical practice, particularly in the pursuit of precision medicine[18]. This convergence leverages the capabilities of genomics, proteomics, and metabolomics to uncover genetic predispositions, monitor disease progression, and provide detailed insights into disease mechanisms. AI, in turn, plays a crucial role in managing and analyzing the vast datasets generated by these omics technologies, extracting actionable insights for improved diagnostics and therapeutics.

Genomics has facilitated the identification of specific genetic predispositions to diseases, while proteomics and metabolomics provide insights into the functional dynamics of disease progression. Together, these disciplines produce complex, data-rich outputs that require advanced computational tools for interpretation. AI-driven machine learning models, including support vector machines and random forests, are increasingly being used to identify biomarkers and patterns in these datasets[19]. This is particularly evident in conditions like GI cancers and inflammatory bowel disease, where AI has been instrumental in detecting mutations and expression patterns associated with disease onset and progression[20,21].

A significant strength of AI lies in its ability to integrate multi-omics datasets. By linking genetic, proteomic, and clinical variables, AI offers a comprehensive perspective on disease mechanisms, enabling more precise diagnoses and personalized treatment plans. This integrative approach significantly enhances physicians' ability to detect diseases at an early stage and predict their trajectories with unprecedented accuracy.

Additionally, AI-assisted imaging technologies further extend the benefits of this integration. Advanced techniques like radiomics and deep learning-based imaging analysis allow for the identification of disease-specific patterns in non-invasive modalities such as radiological scans and histopathological slides[22]. These tools are transforming diagnostics by moving beyond symptom-based assessments to molecularly informed, evidence-based decisions.

While the advancements discussed are undoubtedly transformative, they also present challenges. Issues like data standardization, ethical concerns surrounding AI-driven decision-making, and ensuring equitable access to these technologies remain critical. Addressing these challenges is essential to maximize the potential of omics and AI integration in global healthcare. This paradigm shift underscores the need for continued investment in research, technology, and policy development to ensure its benefits are universally realized.

Ethical issues in AI

Ethical concerns also require attention to ensure equitable access and unbiased care. The ethical implications of using AI in gastroenterology are broad, raising concerns that go beyond technological feasibility and diagnostic accuracy to encompass privacy, equity, data security, patient autonomy, and the dynamics of the physician-patient relationship[23]. As AI-based diagnostic tools like multi-lesion classification models become more embedded in clinical practice, they necessitate robust frameworks to protect patient privacy, especially given their reliance on extensive data for training and operational efficacy[24]. Most AI models draw from vast collections of patient records, including imaging and clinical history data, to build algorithms capable of highly accurate lesion identification. Even with standard practices in anonymization, the risk of re-identifying patient information remains, particularly as datasets grow in size and detail. The challenge lies in implementing stringent data security measures and ensuring compliance with data protection regulations like the General Data Protection Regulation law to mitigate the risks of data breaches and unauthorized data use[25]. Such regulatory frameworks are crucial for establishing trust and accountability in how patient data is handled within AI-driven healthcare[26].

Moreover, the potential for bias within AI models poses another significant ethical concern. If AI algorithms are trained on datasets that overrepresent certain populations – such as a particular age group, ethnicity, or geographic region – their diagnostic accuracy may significantly vary across demographic groups[27]. This variability risks exacerbating healthcare disparities, as some patients might receive less accurate or less effective diagnostics than others[28]. AI models require extensive datasets for training, many with the potential for bias within AI algorithms. AI models are only as unbiased as the data on which they are trained; if a model is trained on data that overrepresents a particular demographic, it may perform sub-optimally or inaccurately when applied to a broader population. This is particularly concerning in a field as diverse as gastroenterology, where diagnostic and disease progression patterns can vary across demographics and ethnicities[29]. Addressing these biases requires that training datasets be representative of diverse patient groups and that models undergo continuous validation to ensure equitable outcomes.

Additionally, as AI tools take on more central roles in diagnostic processes, there is growing concern about the potential for diminished clinical judgment and the impact on physician-patient dynamics. With the increasing accuracy of AI-driven models, there is a risk of over-reliance on machine-generated outputs, which could inadvertently reduce the role of clinician expertise in decision-making[30]. This shift could weaken the nuanced, individualized approach that is often crucial in complex diagnostic cases, where factors beyond raw data, such as the patient's full clinical picture, comorbidities, and preferences, need careful consideration. To mitigate this risk, AI should be implemented as a complementary tool that augments, rather than replaces, clinical judgment[31]. Ethical guidelines that promote a collaborative approach, where AI provides support rather than prescriptive recommendations, can help clinicians maintain a balanced and comprehensive approach to patient care[32].

Furthermore, patient autonomy and informed consent also play essential roles in the ethical application of AI in gastroenterology. Patients have the right to understand how AI is influencing their diagnosis and treatment options. The use of AI in diagnostics, particularly in sensitive areas like cancer detection, underscores the need for transparency around AI's role and capabilities. Informed consent protocols should reflect the complexity of AI integration, ensuring that patients are not only aware of its benefits but also of potential limitations or areas where human oversight is critical [33].

Lastly, the integration of AI into gastroenterology raises regulatory and accountability concerns that extend beyond the clinical setting. As AI models continually learn and adapt, their decision-making processes may become opaque, creating an effect where even the developers or clinicians cannot fully explain why certain recommendations or classifications were made[34,35]. This lack of transparency can impact both clinician trust and patient confidence, particularly in high-stakes diagnoses. Establishing regulatory clinical guidelines and ethical standards that require explainability and accountability in AI algorithms is essential for preserving the integrity of AI-based diagnostics.

In addition to ethical concerns, the practical application of AI in clinical practice is influenced by significant financial limitations. Implementing AI systems often requires substantial investment in technology infrastructure, ongoing maintenance, and specialized training, which may limit accessibility, especially in resource-constrained settings. Furthermore, the attitudes of various stakeholders, including healthcare providers, patients, and regulatory organizations, play a crucial role in the adoption and success of AI in everyday practice. Clinicians' acceptance of AI tools depends on their trust in technology's reliability and the perceived impact on workflow and patient care. Patient attitudes, shaped by concerns over data privacy and the impersonality of AI-driven diagnoses, may also affect adoption. Thus, addressing both the financial implications and stakeholder perspectives is essential for an understanding of AI's potential and limitations in clinical practice.

In summary, the ethical landscape surrounding AI in gastroenterology is complex, underscoring the need for a balanced approach that respects patient rights, fosters equitable care, and preserves the integrity of clinical decision-making. Addressing these ethical challenges is essential to ensuring that AI fulfills its potential to transform diagnostics without compromising fairness, transparency, or patient trust. Through responsible data practices, efforts to mitigate bias, safeguards for patient autonomy, and strong regulatory frameworks, the integration of AI in gastroenterology can align with the core principles of ethical, patient-centered care.

CONCLUSION

Looking to the future, the integration of AI and omics in GI disease management is poised to deepen as technologies advance. Future developments could enable even more comprehensive diagnostic systems that incorporate multimodal data, combining genetic, imaging, and clinical information, for a holistic view of patient health. With these capabilities, AI can become an indispensable tool in personalized medicine, offering tailored treatment plans based on a patient's unique risk factors and disease profile. Yet, as this technology becomes more embedded in clinical practice, it is essential to address the ethical and operational challenges it presents. By fostering a collaborative approach that respects both technological innovation and human expertise, the field of gastroenterology stands to benefit from AI's contributions, ultimately enhancing patient care and outcomes in ways previously thought unattainable.

Regulatory guidelines will also play a crucial role in supporting the safe and effective use of AI, ensuring transparency in AI's decision-making processes and establishing quality standards for AI applications in healthcare.

FOOTNOTES

Author contributions: Ramoni D and Sciricini S wrote the manuscript; Carbone F and Liberale L edited and supervised the work; Montecucco F designed the drafting of the manuscript; all authors have read and approve the final manuscript.

Conflict-of-interest statement: Liberale L is coinventor on the International Patent (WO/2020/226993) filed in April 2020 relating to the use of antibodies that specifically bind interleukin-1 α to reduce various sequelae of ischemia-reperfusion injury to the central nervous system. Liberale L has received speaker fees outside of this work from Daichi-Sankyo. The other authors have no conflict to disclose.

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