ARTIFICIAL INTELLIGENCE AS A PROGNOSTIC TOOL FOR GASTROINTESTINAL TRACT PATHOLOGIES.

INTELIGÊNCIA ARTIFICIAL COMO FERRAMENTA PROGNÓSTICA PARA PATOLOGIAS DO TRATO GASTROINTESTINAL

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Soldera Jonathan [1,2*]

1 University of South Wales, Program of Acute Medicine and Gastroenterology, United Kingdom.
2 Postgraduate Program in Medicine: Pathology, School of Medicine, Universidade Federal de Ciências da Saúde de Porto Alegre, Brasil

ORCID ID:
Soldera Jonathan:
orcid.org/0000-0001-6055-4783

***Corresponding author:** Soldera Jonathan
E-mail: jonathansoldera@gmail.com

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ABSTRACT

Artificial intelligence (AI) has shown significant promise as a prognostic tool in various gastrointestinal tract pathologies, including colorectal cancer, esophageal disorders, inflammatory bowel disease (IBD), liver diseases, and pancreatic disorders. AI algorithms analyze patient data to provide insights into disease progression, treatment response, and prognosis. In gastroenterology, AI has excelled in upper gastrointestinal endoscopy, surpassing human performance in detecting esophageal and gastric cancer. It offers benefits like cancer screening and automated report generation. In IBD, AI predicts disease flare-ups, assesses therapy response, and tailors treatments for individual patients. For liver diseases, AI identifies subtle radiographic features, monitors fibrosis progression, and evaluates treatment response patterns. In pancreatic disorders, AI models predict outcomes, optimize surgeries, and enable targeted therapies. Integrating AI as a prognostic tool brings advantages like processing vast data quickly, enhancing diagnostic accuracy, and aiding in risk stratification and treatment planning. Challenges include ethical considerations and the need for validation through larger studies. Overall, AI has the potential to revolutionize managing gastrointestinal tract pathologies, improving patient outcomes and quality of life.

RESUMO

A inteligência artificial (IA) tem mostrado um grande potencial como ferramenta prognóstica em diversas patologias do trato gastrointestinal, incluindo câncer colorretal, distúrbios esofágicos, doenças inflamatórias intestinais (DII), doenças hepáticas e distúrbios pancreáticos. Algoritmos de IA analisam dados do paciente para fornecer insights sobre a progressão da doença, resposta ao tratamento e prognóstico. Na gastroenterologia, a IA tem se destacado na endoscopia do trato gastrointestinal superior, superando o desempenho humano na detecção de câncer esofágico e gástrico. Ela oferece benefícios como triagem de câncer e geração automatizada de relatórios. Nas DII, a IA prevê crises da doença, avalia a resposta à terapia e personaliza tratamentos para pacientes individuais. Para doenças hepáticas, a IA identifica características radiográficas sutis, monitora a progressão da fibrose e avalia padrões de resposta ao tratamento. Em distúrbios pancreáticos, modelos de IA preveem resultados, otimizam cirurgias e permitem terapias direcionadas. A integração da IA como ferramenta prognóstica traz vantagens como processamento rápido de grandes volumes de dados, aumento da precisão diagnóstica e auxílio na estratificação de riscos e planejamento de tratamento. Desafios incluem considerações éticas e a necessidade de validação por meio de estudos maiores. No geral, a IA tem o potencial de revolucionar o manejo de patologias do trato gastrointestinal, melhorando os resultados e a qualidade de vida dos pacientes.

INTRODUCTION

The advent of Artificial Intelligence (AI) has brought about remarkable transformations across various industries, including the field of medicine. AI has the potential to revolutionize healthcare in gastroenterology by serving as a prognostic tool for gastrointestinal tract pathologies. The history of AI in medicine dates back to 1950, with early models facing limitations that hindered their widespread acceptance and application in medicine [1]. However, advancements in deep learning algorithms in the early 2000s overcame many of these limitations, enabling AI systems to analyze complex algorithms and self-learn [1]. This marked a new era in medicine where AI can be applied to clinical practice, improving diagnostic accuracy, workflow efficiency, and risk assessment models [1].

The evolution of AI in medicine has been significant in recent years, with major applications in gastroenterology and endoscopy [1]. AI-powered medical technologies are rapidly evolving and becoming applicable solutions for clinical practice, leveraging deep learning algorithms to handle large amounts of data from wearables, smartphones, and other mobile monitoring sensors [2]. The application of AI in specific clinical settings, such as the detection of atrial fibrillation, epilepsy seizures, and hypoglycemia, as well as the diagnosis of diseases through histopathological examination or medical imaging, has shown promising results [2]. However, the implementation of augmented medicine and the integration of AI in clinical practice face challenges, including resistance from physicians and the need for validation through traditional clinical trials [2]. Despite these challenges, the benefits of AI applications in clinical practice are becoming increasingly apparent, leading to discussions about its future opportunities and risks on physicians, healthcare institutions, medical education, and bioethics [2].

As laboratory medicine continues to evolve from a mainly manual profession to a highly automated discipline, generating vast amounts of diagnostic data, AI algorithms are poised to play a crucial role in structuring and making sense of this data, merging the worlds of the laboratory and clinics [3]. By providing valuable suggestions in diagnosis, prognosis, and therapeutic options, AI can enhance the efficiency and accuracy of medical decision-making, freeing physicians' time to focus more on patient care [3]. However, the implementation of AI algorithms in healthcare also poses challenges and requires careful consideration of the ethical implications and potential impact on healthcare workers [3].

This editorial delves into the role of AI in prognostication for these conditions, highlighting its benefits, challenges, and future prospects.

AI in Gastrointestinal Tract Pathologies

In the domain of gastroenterology, AI algorithms have shown great potential as prognostic tools for gastrointestinal tract pathologies, such as inflammatory bowel disease, colorectal cancer, and gastroesophageal reflux disease. By analyzing extensive patient data, including medical records, imaging studies, and laboratory results, AI algorithms can provide valuable insights into disease progression, treatment response, and overall prognosis [4].

The application of AI in upper gastrointestinal endoscopy has gained significant attention in recent years. AI systems have been developed to assist in the assessment of (pre-)cancerous lesions of the gastrointestinal tract. These systems have shown promising results in several areas, including the detection, characterization, and delineation of esophageal and gastric cancer, prediction of tumor invasion, and detection of Helicobacter pylori [5]. AI algorithms have demonstrated high accuracy rates of up to 99% in detecting superficial and advanced upper GI cancers, surpassing the performance of trainee and experienced endoscopists [5]. Additionally, AI has outperformed mid-level and trainee endoscopists, although not expert endoscopists, in the detection of esophageal lesions and atrophic gastritis [5]. The integration of AI in upper gastrointestinal endoscopy holds the potential to improve early diagnosis of esophageal and gastric cancer and enhance the identification of patients suitable for endoscopic resection [5].

The field of gastrointestinal endoscopy has witnessed significant advancements in the application of AI. AI-assisted endoscopy has the potential to revolutionize the practice of gastroenterologists, offering benefits such as cancer screening and automated report generation [6]. Over the years, AI has made remarkable progress in endoscopy, with the development of sophisticated models and potential applications that encompass various aspects of modern endoscopic practice [6]. These AI models have the ability to enhance diagnostic accuracy, risk stratification, and pathologic identification, paving the way for improved patient care in gastroenterology [6]. However, it is important to acknowledge the limitations of AI and understand its role as a tool to enhance human decision-making rather than replace healthcare professionals [6].

Colorectal Cancer

Colorectal cancer (CRC) is a significant contributor to morbidity and mortality on a global scale. The application of AI algorithms has demonstrated remarkable success in analyzing medical images, including colonoscopy and histopathological slides. These AI systems assist in the early detection of precancerous lesions and accurate staging of tumors, enabling clinicians to make informed decisions regarding treatment strategies, personalized therapies, and prognostic predictions. The advancements in AI technology, such as machine learning and deep learning, have revolutionized the field of medicine, offering promising prospects for various applications, including medical image recognition, biotechnology, auxiliary diagnosis, drug research and development, and nutrition [7-9].

CRC is a common gastrointestinal malignancy that poses a serious threat to human health, with high mortality rates. Many CRC cases arise from the malignant transformation of colorectal polyps. Therefore, early diagnosis and treatment play a crucial role in determining the prognosis of CRC. Diagnostic methods for CRC include imaging diagnosis, endoscopy, and pathology diagnosis, while treatment options encompass endoscopic treatment, surgical treatment, and drug treatment [7].

AI technology, although currently in its nascent stage, predominantly focuses on image recognition and auxiliary analysis, lacking in-depth communication capabilities with patients. Nonetheless, its potential to revolutionize CRC diagnosis, treatment, and prognosis is significant. By leveraging AI, clinicians can identify high-risk patients, devise precise and personalized treatment plans, and predict prognoses with greater accuracy [8].

The integration of AI technology in the diagnosis, treatment, and prognosis of CRC holds immense promise for improving patient outcomes. Further research and development in this field are needed to harness the full potential of AI in CRC management [7-9]. One practical application of AI in CRC prognostication is the development of predictive models that utilize machine learning algorithms to analyze clinical and molecular data. These models can help clinicians assess the likelihood of disease progression, recurrence, and patient survival based on individual patient characteristics and tumor features. By integrating diverse data sources and considering multiple variables, AI-driven prognostic models have the potential to enhance treatment decision-making and improve patient outcomes in CRC. [8]

Esophageal Disorders

Esophageal disorders encompass a wide range of conditions, including gastroesophageal reflux disease (GERD) and esophageal cancer. The integration of artificial intelligence (AI) models has shown significant potential in predicting disease progression, identifying high-risk individuals, and guiding therapeutic interventions for patients with esophageal disorders. These AI models analyze clinical data, such as patient history, endoscopic findings, and imaging studies, to optimize treatment plans and improve long-term outcomes [10-13].

AI has shown promise in the prognostication of esophageal disorders by utilizing advanced predictive modeling techniques. By analyzing a combination of clinical data, including patient demographics, medical history, and diagnostic test results, AI algorithms can generate personalized prognostic assessments. These assessments provide valuable insights into disease progression, treatment response, and long-term outcomes, enabling clinicians to make informed decisions and optimize patient care strategies [10-13].

Several studies have demonstrated the effectiveness of AI techniques, particularly deep learning and convolutional neural networks, in analyzing endoscopic images and videos for the early detection and characterization of esophageal neoplasia [10,13]. Furthermore, AI-based approaches have the potential to facilitate pathological diagnosis, gene diagnosis, and risk stratification models, although further clinical research is needed for validation [12,13]. The use of AI-powered decision support systems empowers clinicians to enhance their treatment strategies and achieve better results for patients with esophageal disorders [11].

Inflammatory Bowel Disease

Inflammatory Bowel Disease (IBD), encompassing Crohn's disease and ulcerative colitis, is characterized by chronic inflammation of the gastrointestinal tract. The management of IBD can be challenging due to its multifactorial nature, involving factors such as host genetics, the immune system, environmental influences, and the gut microbiome. To address these challenges, AI-based algorithms have been developed to integrate multiple data sources, including patient-reported outcomes, genetic profiles, and biomarkers. These algorithms have shown promise in predicting disease flare-ups, assessing therapy response, and tailoring treatment strategies for individual patients [14,15].

The application of AI in IBD research has been facilitated by technological advancements such as next-generation sequencing, high-throughput omics data generation, and molecular networks [15]. Machine learning and systems biology, which are subsets of AI, enable the efficient integration and interpretation of large datasets, leading to the discovery of clinically relevant knowledge. For example, machine learning approaches can facilitate patient stratification, prediction of disease progression, and therapy responses, ultimately allowing for personalized treatment options that improve patient outcomes and reduce costs [15,16].

Studies have demonstrated the potential of AI in various aspects of IBD care. For instance, AI has been applied in the diagnosis, follow-up, treatment selection, and prognosis of IBD. It has also been utilized in the analysis of histopathology, endoscopy, and imaging, highlighting its role in improving disease assessment [17,18]. AI-driven predictive models have shown promise in identifying features and patterns across diverse datasets, leading to insights that can enhance disease management. These models have the potential to transform clinical practice by providing personalized metrics for disease outcomes [19].

Despite the potential benefits, there are challenges associated with the implementation of AI in clinical IBD research. Technical barriers, bias within datasets, and the need for validation in larger cohorts are among the obstacles that need to be addressed. Ethical considerations related to the use of AI in healthcare and data interpretation/validation are also important aspects to be taken into account [18,20].

AI-based approaches have the potential to revolutionize the management of IBD by integrating diverse data sources and providing personalized insights for patients. By leveraging machine learning and systems biology, AI algorithms can enhance disease assessment, prediction, and treatment selection, ultimately improving patient outcomes and quality of life.

Liver Diseases

Liver diseases, including non-alcoholic fatty liver disease (NAFLD) and viral hepatitis, have a significant impact on global healthcare systems. Detecting and managing these diseases is crucial for patient outcomes. AI algorithms trained on extensive datasets can help identify subtle radiographic features, monitor fibrosis progression, and assess treatment response patterns. By leveraging machine learning models, healthcare professionals can identify patients at risk, intervene in a timely manner, and make accurate prognostic assessments to guide clinical management decisions, such as liver transplantation. For example, machine learning models have been developed to predict major adverse cardiovascular events after orthotopic liver transplantation, providing valuable insights for recipient selection and identifying individuals at elevated risk for post-transplantation MACE [21]. Another study utilized a machine learning algorithm to predict 30-day and 365-day mortality after liver transplantation, achieving high accuracy in predicting patient outcomes [22]. Furthermore, these tools have demonstrated effectiveness in challenging scenarios, such as predicting post-LT major adverse cardiac events [23]. Additionally, machine learning algorithms have been applied to predict rebleeding and mortality for oesophageal variceal bleeding in cirrhotic patients, outperforming other assessment tools like CLIF-SOFA and MELD score [24]. Such tool has been also prospectively validated [25]. Deep learning techniques have also been employed to improve the imaging diagnosis of hepatocellular carcinoma, aiding in the detection and diagnosis of this type of liver cancer [26]. This demonstrates the potential of AI and machine learning in liver disease management and highlight the value of integrating these technologies into clinical practice.

Pancreatic Disorders

Pancreatic disorders, such as pancreatitis and pancreatic cancer, often manifest with late-stage symptoms and poor prognoses. The integration of AI models can significantly impact the field of pancreatic disease by analyzing clinical records, genetic information, and medical imaging to predict disease outcomes, optimize surgical interventions, and enable targeted therapies[25-28]. For instance, AI can be utilized in endoscopic ultrasound (EUS) for pancreatic disorders, where it aids in computer-aided diagnosis (CAD) by extracting and selecting features from imaging data and utilizing deep learning-based algorithms[25]. By leveraging AI's predictive capabilities, clinicians can intervene at an earlier stage, potentially improving survival rates and patient outcomes[25-28]. Additionally, AI can contribute to early detection of pancreatic cancer through the use of medical images, pathological examination, biomarkers, and other aspects, leading to the early screening of high-risk groups and lesions[28]. It can also predict prognosis, recurrence risk, metastasis, and therapy response, influencing patient outcomes[28]. Furthermore, AI finds applications in pancreatic cancer health records, estimating medical imaging parameters, and developing computer-aided diagnosis systems[28]. The advancement of AI applications in pancreatic disorders requires collaboration among clinicians, researchers, and engineers, as well as continuous efforts to overcome limitations and harness the power of computing in the fight against pancreatic cancer[27,28]. By incorporating AI into the management of pancreatic disorders, healthcare professionals can potentially improve the detection, treatment, and overall prognosis of patients.

Benefits of AI in Prognostication

The integration of AI as a prognostic tool for gastrointestinal tract pathologies provides several significant advantages. AI enables the processing of vast amounts of data in a shorter timeframe, leading to timely and accurate prognostic information for clinicians. AI algorithms have the capability to detect subtle patterns and associations that may go unnoticed by humans, thereby enhancing diagnostic accuracy and prognostic precision. This can aid in risk stratification, treatment planning, and optimizing patient outcomes[29]. Recent advancements in computing technology and the application of AI in various fields, including medical practice, have increased the potential for improved outcomes [30]. AI algorithms can process complex mathematical data, allowing for the consideration of multiple parameters and sophisticated formulas to determine conclusions that would be impractical or impossible for humans alone [30]. This individualized approach could lead to more tailored treatments for each patient. However, it is important to note that most studies conducted so far are retrospective and further evaluation through large-scale prospective studies is needed [30]. In addition to medical challenges, the implementation of AI on a large scale raises ethical and financial considerations[30].

AI, particularly deep learning, has the potential to enhance GI endoscopy in various areas, including lesion detection, classification, quality metrics, and documentation [31]. Computer vision in endoscopy powered by advanced machine learning algorithms can improve prediction and treatment outcomes for patients with GI disorders and cancer [31]. The availability of large libraries of endoscopic images, such as "EndoNet," can facilitate the development and application of AI systems [31]. The regulatory environment for AI implementation is evolving, with colon polyp detection highlighted as a potential clinical trial endpoint [31]. Ongoing collaboration among gastroenterologists, industry experts, and regulatory agencies is crucial to ensure rapid progress and meaningful clinical impact [31].

AI and machine learning also have potential applications in the field of liver disease, particularly in acute on chronic liver failure (ACLF) [32]. AI methods, including predictive, prognostic, probabilistic, and simulation modeling, can minimize cognitive load and impact short-term and long-term patient outcomes [32]. However, ethical considerations and a lack of proven benefits temper the enthusiasm for AI implementation [32]. AI models can contribute to the understanding of morbidity and mortality mechanisms in ACLF [32]. The impact of AI on patient-centered outcomes and other aspects of patient care is still uncertain [32].

In the field of pancreatic cystic lesions (PCLs), radiomics combined with machine learning and AI methods has the potential to differentiate between benign and malignant lesions, leading to improved clinical decision-making and resource utilization [33]. Radiomics involves quantitative image analysis to extract features and develop imaging biomarkers for predicting high-risk PCLs [33]. However, further studies are needed to validate the clinical application of radiomics [33].

AI and big data analysis have significantly influenced clinical oncology and research [34]. Next-generation sequencing (NGS) platforms, coupled with AI and machine learning, enable the identification of novel biomarkers, therapeutic targets, and accurate prognosis in cancer [34]. However, challenges and limitations, such as data analysis and validation, remain [34].

While AI and ML promise transformative changes in healthcare, there are provisos that need to be addressed. Reliability of input data, interpretation of output data, data privacy, liability issues, decreased human interaction, patient satisfaction, affordability, and skepticism regarding cost-benefit are important considerations [34].

Challenges and Limitations

Despite the promising potential of AI in prognostication, there are several challenges and limitations that need to be addressed. The availability of high-quality data is crucial for effectively training AI algorithms[35]. However, concerns related to data privacy and ethical considerations surrounding the use of patient information must be carefully addressed to ensure patient confidentiality and establish trust[35]. Improving the interpretability and transparency of AI algorithms is also necessary to enable clinicians to understand and validate the reasoning behind the generated prognostic predictions[35].

In a study on AI in primary health care, experts reported that AI has the potential to improve managerial and clinical decisions and processes[35]. Common data standards would facilitate the realization of this potential[35]. However, there was no consensus among the experts regarding whether AI applications should learn and adapt to clinician preferences or behavior, and they did not agree on the extent of AI's potential harm to patients[35]. Assessing the impact of AI-based applications on continuity and coordination of care was found to be more challenging[35].

In the field of surgery, AI has shown promise but also comes with certain limitations[36]. Machine learning, artificial neural networks, natural language processing, and computer vision are the main subfields of AI with applications in surgery[36]. These applications include big data analytics and clinical decision support systems[36]. Surgeons have the opportunity to integrate AI into modern practice, partnering with data scientists to capture data and provide clinical context[36]. This collaboration has the potential to revolutionize surgery and improve patient care.

In drug discovery, AI has gained traction and is increasingly being used to accelerate the process[36,37]. AI techniques, such as machine learning and deep learning, have been applied to various aspects of drug discovery, including quantitative structure-activity/ property relationship modeling, de novo molecular design, and chemical synthesis prediction[37]. These AI-driven approaches have the potential to address some of the challenges in CNS drug discovery[38]. They can aid in target identification, compound screening, hit/lead generation and optimization, drug response and synergy prediction, de novo drug design, and drug repurposing[38]. However, there are still limitations and challenges to be overcome, such as the need for large amounts of annotated data and issues with interpretability[37,38].

In the field of nuclear medicine, AI has the potential to impact various aspects of the profession[39]. It can be applied to different stages of the imaging workflow, including planning, scanning, interpretation, and reporting[39]. However, current AI techniques have limitations, such as the need for interpretability and the requirement for large amounts of annotated data[39].

Future Prospects

The future of AI in prognostication for gastrointestinal tract pathologies holds immense potential. As AI algorithms continue to evolve and improve, their integration with electronic health records and imaging systems can enhance real-time decision-making and facilitate personalized treatment approaches[35,39]. Collaboration between clinicians, data scientists, and AI experts is essential to develop robust and reliable AI models specifically tailored to gastrointestinal diseases [35,39]. For example, in the field of peptic ulcers, AI has shown promising applications in pathogenic factor identification, diagnosis, and management[35]. AI can aid in the identification of Helicobacter pylori (Hp) infection, differential diagnosis, and management of complications such as bleeding, obstruction, perforation, and canceration[35]. These AI-based tools have the potential to improve the management of peptic ulcer patients[35]. Similarly, in colonoscopy, AI has the potential to enhance the early identification, resection, and treatment of precancerous adenoma and early-stage cancer, leading to a reduction in colorectal cancer prevalence and mortality[40]. AI technologies, such as computer-aided detection and diagnosis (CAD), can provide decision support during colonoscopy, increasing the adenoma detection rate and improving the effectiveness of screening[41]. The future prospects of AI in colonoscopy include improving diagnostic performance, reducing costs, optimizing endoscopic schedules, and addressing limitations and challenges[41]. AI also holds potential in the management of inflammatory bowel disease (IBD)[42]. AI applications in IBD range from genomics to endoscopic applications, enabling disease classification, stratification, self-monitoring, and personalized management[42]. The practical applications of AI in IBD are already being used, and the future holds further potential for AI to enhance patient care[42].

As AI becomes increasingly embedded in healthcare, ethical considerations must remain at the forefront[35]. Transparency in AI algorithms and effective communication of their limitations to patients and healthcare providers are essential[35]. Respecting patient autonomy, privacy, and informed consent are crucial during the development and implementation of AI-based prognostic tools[35]. It is important to ensure that AI complements clinical decision-making and does not replace the human touch and personalized care that patients deserve[35].

CONCLUSION

The integration of Artificial Intelligence as a prognostic tool for gastrointestinal tract pathologies holds tremendous promise in revolutionizing disease management and treatment strategies. AI has the potential to improve diagnostic accuracy, enhance prognostic precision, and ultimately optimize patient outcomes. However, addressing challenges such as data quality, ethical concerns, and algorithm transparency is vital for the successful implementation of AI in routine clinical practice. Through collaborative efforts and ongoing research, AI can become an invaluable asset in the fight against gastrointestinal diseases, equipping clinicians with powerful tools for prognostication and patient-centered care.

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