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**Scope and caveats: Artificial intelligence in gastroenterology**

Sridhar GR *et al*. AI in Gastroenterology

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**Abstract**

The use of Artificial intelligence (AI) has evolved from its mid-20th century origins to playing a pivotal tool in modern medicine. It leverages digital data and computational hardware for diverse applications, including diagnosis, prognosis, and treatment responses in gastrointestinal and hepatic conditions. AI has had an impact in techniques, particularly endoscopy, ultrasound, and histopathology. AI encompasses machine learning, natural language processing, and robotics, with machine learning being central. This involves sophisticated algorithms capable of managing complex datasets, far surpassing traditional statistical methods. These algorithms, both supervised and unsupervised, are integral for interpreting large datasets. In liver diseases, AI's non-invasive diagnostic applications, particularly in non-alcoholic fatty liver disease, and its role in characterizing hepatic lesions is promising. AI aids in distinguishing between normal and cirrhotic livers and improves the accuracy of lesion characterization and prognostication of hepatocellular carcinoma. AI enhances lesion identification during endoscopy, showing potential in the diagnosis and management of early-stage esophageal carcinoma. In peptic ulcer disease, AI technologies influence patient management strategies. AI is useful in colonoscopy, particularly in detecting smaller colonic polyps. However, its applicability in non-academic settings requires further validation. Addressing these issues is vital for harnessing the potential of AI. In conclusion, while AI offers transformative possibilities in gastroenterology, careful integration and balancing of technical possibilities with ethical and practical application, is essential for optimal use.

**Key Words:** Machine learning; Neural networks; Diagnosis; Work-flow; Ethics; Image; Polyps; Hepatoma

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**Core Tip:** Artificial intelligence helps in the early identification, management and prognostication of gastrointestinal diseases through applications in endoscopy and histopathological interpretation. Proof of concept studies exist for all of these, but need validation by randomized clinical trials before they can be incorporated into clinical work flow.

**INTRODUCTION**

Artificial intelligence (AI) has origins dating back to the mid-20th century[1]. Its application, particularly in gastroenterology, has been more recent, being dependent on the availability of digital data and powerful computational hardware. AI is now used in diagnosing and predicting treatment responses for a spectrum of gastrointestinal and hepatic disorders[2-5].

AI encompasses multiple fields and is often defined as a computer's ability to perform tasks requiring human-like cognition[5], or as a machine that simulates complex human thinking[2].

In contrast to traditional statistical methods, AI processes data using a large number of variables and sophisticated formulas, making it possible to perform otherwise impractical analyses[2].

**NOMENCLATURE AND CLASSIFICATION OF AI**

AI broadly includes three areas: (1) machine learning, which involves artificial neural networks, deep learning, and convolutional neural networks; (2) natural language processing; and (3) robotics. In gastroenterology, machine learning techniques are principally used[6].

Machine learning can be considered an advanced statistical approach to uncover relationships among various parameters; it utilizes algorithms such as linear regression for predicting relationships between variables, and classification algorithms like support vector machines and random forests for categorizing data.

Neural networks are more complex, utilizing nodes to determine calculated parameters, thereby allowing the use of intricate formulas. Deep learning networks, which are multi-layered, enable more advanced learning, are used in image processing[2].

Machine learning models are categorized into supervised and unsupervised. Supervised models label each sample, while unsupervised models aim to discover data structures without labels.

**APPLICATIONS OF AI IN GASTROENTEROLOGY**

AI's applications in gastroenterology promise to enhance patient care by reducing diagnostic errors[6]. They are employed in various conditions including gastritis, gastrointestinal bleeding, gastric malignancy, non-alcoholic fatty liver disease (NAFLD), cirrhosis, inflammatory bowel disease, colorectal polyps and cancer, and computer-aided endoscopy. Other potential applications include Helicobacter pylori infection, celiac disease, and pancreatic lesions[5]. A MEDLINE database search indicates that China and the USA are leading in AI research in this field[3].

**LIVER DISEASES**

In liver diseases, AI applications span from hepatocellular carcinoma to NAFLD, benign tumours, and viral hepatitis.

Non-invasive methods like ultrasound or transient elastography are used to identify NAFLD, now classified as metabolic dysfunction-associated steatohepatitis[7]. Probabilistic neural networks differentiate normal livers from those with cirrhosis in NAFLD patients, with the gold standard being liver biopsy. The area under the curve for this method ranges between 0.857 and 0.901[8]. AI also aids in automating histopathological examination, achieving high accuracy in characterizing alterations found in NAFLD[9]. Predictive models using multiple data sources, including electronic medical records, imaging, and biomarkers, have improved accuracy in identifying at-risk patients[10,11].

Hepatic mass lesions can be interpreted with high accuracy by the use of AI. Deep learning methods achieved receiver operating curves of 0.93 in lesion differentiation and 0.916 in characterization[12]. AI also aids in prognosticating established hepatocellular carcinoma[11] and predicting graft failure following liver transplantation[4].

However, when compared with standard scores, AI did not significantly improve the accuracy of short-term predictions for readmission and mortality risks in patients with cirrhosis[13].

**ESOPHAGEAL LESIONS**

AI methodologies improved the identification of suspicious lesions during upper GI endoscopy; this was reported in the differentiation of dysplasia and early neoplastic changes in Barrett's esophagus[14]. Other technologies such as white-light endoscopy/narrow band imaging, wide-area transepithelial sampling, and volumetric laser endomicroscopy lend themselves to machine learning[14]. As of 2020, AI algorithms were shown to be effective in diagnosing and thereby improving the outcomes of early-stage esophageal carcinoma.

**ACID PEPTIC DISORDERS**

In peptic ulcer disease, AI is useful in diagnosis, management, and complications[15]. Helicobacter pylori, a significant pathogenic factor, can be identified using AI. The first application was reported in 2004[16]; recent studies employ convoluted neural network models on large datasets, achieving high sensitivity, specificity, and accuracy[17].

AI also assists in diagnosing and differentiating peptic ulcers with wireless capsule endoscopic images by the use of deep learning[18,19]. It achieved an overall sensitivity of 89.7%. AI can also help identify infections, ulcers, polyps, and submucosal xanthomas[20,21].

For rare cases requiring surgical intervention, AI finds application in robot-assisted minimally invasive surgery, and in predicting complications like bleeding and perforation by the use of data from electronic medical records[15,22].

**COLONOSCOPY**

AI aids in classifying structures and has notably improved polyp detection rates, particularly in identifying polyps less than 5cm in size[2]; these are often missed by conventional procedures.

AI is also effective in grading remission of ulcerative colitis[23,24] and in assessing video capsule endoscopy for ulcers and bleeding detection, which is a time-consuming task[25].

However, mixed results were reported for polyp detection using computer-aided endoscopy in non-academic community-based practice[26], indicating the need for further studies[27].

**PROS AND CONS OF AI IN GASTROENTEROLOGY**

The potential of AI to enhance care quality is significant, but integration into clinical workflows remains a challenge[28]. In specific tasks, AI-based devices match or even surpass expert gastroenterologists in identifying and differentiating neoplasms in the gastrointestinal tract. However, for routine clinical practice adoption, randomized trial validation is necessary[28].

Other factors such as disease prevalence, physician competence, and human-machine interaction also affect AI's clinical benefit[29]. Despite the availability of commercial AI tools in the USA and Europe, their integration into clinical workflows is still a work in progress before the full potential is realized[30].

**ETHICAL AND LEGAL ASPECTS**

The growing use of AI in clinical practice brings ethical and legal challenges such as data privacy and security, method reliability and safety, and ensuring fairness, inclusivity, transparency, and accountability[31]. The extent of reliance on AI for decision-making is a key consideration[28], given that the ultimate responsibility rests on the end user, viz the physician.

AI has the potential for bias in clinical problem selection, variable choices, algorithm development, and system use[32]. In gastroenterology, as in other fields, training sets must be inclusive and diverse to avoid bias in diagnosing diseases with varying prevalence rates.

To mitigate potential biases, health equity goals should be incorporated early in algorithm development by involving technically diverse research teams. Regulatory standards should include pre-deployment audits to ensure algorithmic performance equality[32].

**CONCLUSION**

AI in gastroenterology has primarily been applied in endoscopic image analysis, radiology, and histopathology to aid in early detection of lesions and appropriate treatment. While its role in diagnostic endoscopy is expanding, evidence for improved clinical outcomes in real-life scenarios remains to be established.

Issues surrounding human-machine interaction, AI integration into clinical culture and practice, and the balance between AI-assisted management and practitioner skill maintenance need to be addressed[33]. Generative AI, such as ChatGPT, launched in late November 2022[34], has become pervasive in medicine, including gastroenterology. While beneficial in diagnosis in complex scenarios[35], privacy and legal concerns arise, especially when scientific publications could eventually heavily on AI-generated results[36].

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**REFERENCES**

1 **Turing** **AM**. I.—Computing machinery and intelligence. *Mind* 1950; **LIX**: 433–460 [DOI: 10.1093/mind/LIX.236.433]

2 **Moldoveanu AC**, Fierbinteanu-Braticevici C. A Primer into the Current State of Artificial Intelligence in Gastroenterology. *J Gastrointestin Liver Dis* 2022; **31**: 244-253 [PMID: 35694986 DOI: 10.15403/jgld-4180]

3 **Nam D**, Chapiro J, Paradis V, Seraphin TP, Kather JN. Artificial intelligence in liver diseases: Improving diagnostics, prognostics and response prediction. *JHEP Rep* 2022; **4**: 100443 [PMID: 35243281 DOI: 10.1016/j.jhepr.2022.100443]

4 **Stan-Ilie M**, Sandru V, Constantinescu G, Plotogea OM, Rinja EM, Tincu IF, Jichitu A, Carasel AE, Butuc AC, Popa B. Artificial Intelligence-The Rising Star in the Field of Gastroenterology and Hepatology. *Diagnostics (Basel)* 2023; **13** [PMID: 36832150 DOI: 10.3390/diagnostics13040662]

5 **Correia FP**, Lourenço LC. Artificial intelligence application in diagnostic gastrointestinal endoscopy - Deus ex machina? *World J Gastroenterol* 2021; **27**: 5351-5361 [PMID: 34539137 DOI: 10.3748/wjg.v27.i32.5351]

6 **Poalelungi DG**, Musat CL, Fulga A, Neagu M, Neagu AI, Piraianu AI, Fulga I. Advancing Patient Care: How Artificial Intelligence Is Transforming Healthcare. *J Pers Med* 2023; **13** [PMID: 37623465 DOI: 10.3390/jpm13081214]

7 **Rinella ME**, Lazarus JV, Ratziu V, Francque SM, Sanyal AJ, Kanwal F, Romero D, Abdelmalek MF, Anstee QM, Arab JP, Arrese M, Bataller R, Beuers U, Boursier J, Bugianesi E, Byrne CD, Castro Narro GE, Chowdhury A, Cortez-Pinto H, Cryer DR, Cusi K, El-Kassas M, Klein S, Eskridge W, Fan J, Gawrieh S, Guy CD, Harrison SA, Kim SU, Koot BG, Korenjak M, Kowdley KV, Lacaille F, Loomba R, Mitchell-Thain R, Morgan TR, Powell EE, Roden M, Romero-Gómez M, Silva M, Singh SP, Sookoian SC, Spearman CW, Tiniakos D, Valenti L, Vos MB, Wong VW, Xanthakos S, Yilmaz Y, Younossi Z, Hobbs A, Villota-Rivas M, Newsome PN; NAFLD Nomenclature consensus group. A multisociety Delphi consensus statement on new fatty liver disease nomenclature. *J Hepatol* 2023; **79**: 1542-1556 [PMID: 37364790 DOI: 10.1016/j.jhep.2023.06.003]

8 **Lee JH**, Joo I, Kang TW, Paik YH, Sinn DH, Ha SY, Kim K, Choi C, Lee G, Yi J, Bang WC. Deep learning with ultrasonography: automated classification of liver fibrosis using a deep convolutional neural network. *Eur Radiol* 2020; **30**: 1264-1273 [PMID: 31478087 DOI: 10.1007/s00330-019-06407-1]

9 **Teramoto T**, Shinohara T, Takiyama A. Computer-aided classification of hepatocellular ballooning in liver biopsies from patients with NASH using persistent homology. *Comput Methods Programs Biomed* 2020; **195**: 105614 [PMID: 32650090 DOI: 10.1016/j.cmpb.2020.105614]

10 **Pournik O**, Dorri S, Zabolinezhad H, Alavian SM, Eslami S. A diagnostic model for cirrhosis in patients with non-alcoholic fatty liver disease: an artificial neural network approach. *Med J Islam Repub Iran* 2014; **28**: 116 [PMID: 25678995]

11 **Calderaro J**, Seraphin TP, Luedde T, Simon TG. Artificial intelligence for the prevention and clinical management of hepatocellular carcinoma. *J Hepatol* 2022; **76**: 1348-1361 [PMID: 35589255 DOI: 10.1016/j.jhep.2022.01.014]

12 **Schmauch B**, Herent P, Jehanno P, Dehaene O, Saillard C, Aubé C, Luciani A, Lassau N, Jégou S. Diagnosis of focal liver lesions from ultrasound using deep learning. *Diagn Interv Imaging* 2019; **100**: 227-233 [PMID: 30926443 DOI: 10.1016/j.diii.2019.02.009]

13 **Hu C**, Anjur V, Saboo K, Reddy KR, O'Leary J, Tandon P, Wong F, Garcia-Tsao G, Kamath PS, Lai JC, Biggins SW, Fallon MB, Thuluvath P, Subramanian RM, Maliakkal B, Vargas H, Thacker LR, Iyer RK, Bajaj JS. Low Predictability of Readmissions and Death Using Machine Learning in Cirrhosis. *Am J Gastroenterol* 2021; **116**: 336-346 [PMID: 33038139 DOI: 10.14309/ajg.0000000000000971]

14 **Lazăr DC**, Avram MF, Faur AC, Goldiş A, Romoşan I, Tăban S, Cornianu M. The Impact of Artificial Intelligence in the Endoscopic Assessment of Premalignant and Malignant Esophageal Lesions: Present and Future. *Medicina (Kaunas)* 2020; **56** [PMID: 32708343 DOI: 10.3390/medicina56070364]

15 **Zhao PY**, Han K, Yao RQ, Ren C, Du XH. Application Status and Prospects of Artificial Intelligence in Peptic Ulcers. *Front Surg* 2022; **9**: 894775 [PMID: 35784921 DOI: 10.3389/fsurg.2022.894775]

16 **Huang CR**, Sheu BS, Chung PC, Yang HB. Computerized diagnosis of Helicobacter pylori infection and associated gastric inflammation from endoscopic images by refined feature selection using a neural network. *Endoscopy* 2004; **36**: 601-608 [PMID: 15243882 DOI: 10.1055/s-2004-814519]

17 **Shichijo S**, Nomura S, Aoyama K, Nishikawa Y, Miura M, Shinagawa T, Takiyama H, Tanimoto T, Ishihara S, Matsuo K, Tada T. Application of Convolutional Neural Networks in the Diagnosis of Helicobacter pylori Infection Based on Endoscopic Images. *EBioMedicine* 2017; **25**: 106-111 [PMID: 29056541 DOI: 10.1016/j.ebiom.2017.10.014]

18 **Al-Kasasbeh R**, Korenevskiy N, Alshamasin M, Ionescou F, Smith A. Prediction of gastric ulcers based on the change in electrical resistance of acupuncture points using fuzzy logic decision-making. *Comput Methods Biomech Biomed Engin* 2013; **16**: 302-313 [PMID: 22292589 DOI: 10.1080/10255842.2011.618926]

19 **Wang S**, Xing Y, Zhang L, Gao H, Zhang H. A systematic evaluation and optimization of automatic detection of ulcers in wireless capsule endoscopy on a large dataset using deep convolutional neural networks. *Phys Med Biol* 2019; **64**: 235014 [PMID: 31645019 DOI: 10.1088/1361-6560/ab5086]

20 **Mohammad F**, Al-Razgan M. Deep Feature Fusion and Optimization-Based Approach for Stomach Disease Classification. *Sensors (Basel)* 2022; **22** [PMID: 35408415 DOI: 10.3390/s22072801]

21 **Xia J**, Xia T, Pan J, Gao F, Wang S, Qian YY, Wang H, Zhao J, Jiang X, Zou WB, Wang YC, Zhou W, Li ZS, Liao Z. Use of artificial intelligence for detection of gastric lesions by magnetically controlled capsule endoscopy. *Gastrointest Endosc* 2021; **93**: 133-139.e4 [PMID: 32470426 DOI: 10.1016/j.gie.2020.05.027]

22 **Gao S**, Ji S, Feng M, Lu X, Tong W. A study on autonomous suturing task assignment in robot-assisted minimally invasive surgery. *Int J Med Robot* 2021; **17**: 1-10 [PMID: 33049099 DOI: 10.1002/rcs.2180]

23 **Stidham RW**, Liu W, Bishu S, Rice MD, Higgins PDR, Zhu J, Nallamothu BK, Waljee AK. Performance of a Deep Learning Model *vs* Human Reviewers in Grading Endoscopic Disease Severity of Patients With Ulcerative Colitis. *JAMA Netw Open* 2019; **2**: e193963 [PMID: 31099869 DOI: 10.1001/jamanetworkopen.2019.3963]

24 **Gottlieb K**, Requa J, Karnes W, Chandra Gudivada R, Shen J, Rael E, Arora V, Dao T, Ninh A, McGill J. Central Reading of Ulcerative Colitis Clinical Trial Videos Using Neural Networks. *Gastroenterology* 2021; **160**: 710-719.e2 [PMID: 33098883 DOI: 10.1053/j.gastro.2020.10.024]

25 **Aoki T**, Yamada A, Aoyama K, Saito H, Tsuboi A, Nakada A, Niikura R, Fujishiro M, Oka S, Ishihara S, Matsuda T, Tanaka S, Koike K, Tada T. Automatic detection of erosions and ulcerations in wireless capsule endoscopy images based on a deep convolutional neural network. *Gastrointest Endosc* 2019; **89**: 357-363.e2 [PMID: 30670179 DOI: 10.1016/j.gie.2018.10.027]

26 **Wei MT**, Shankar U, Parvin R, Abbas SH, Chaudhary S, Friedlander Y, Friedland S. Evaluation of Computer-Aided Detection During Colonoscopy in the Community (AI-SEE): A Multicenter Randomized Clinical Trial. *Am J Gastroenterol* 2023; **118**: 1841-1847 [PMID: 36892545 DOI: 10.14309/ajg.0000000000002239]

27 **Berzin TM**, Glissen Brown J. Navigating the "Trough of Disillusionment" for CADe Polyp Detection: What Can We Learn About Negative AI Trials and the Physician-AI Hybrid? *Am J Gastroenterol* 2023; **118**: 1743-1745 [PMID: 37141122 DOI: 10.14309/ajg.0000000000002286]

28 **Hassan C**, Mori Y, Sharma P. The Pros and Cons of Artificial Intelligence in Endoscopy. *Am J Gastroenterol* 2023; **118**: 1720-1722 [PMID: 37052360 DOI: 10.14309/ajg.0000000000002287]

29 **Frazzoni L**, Arribas J, Antonelli G, Libanio D, Ebigbo A, van der Sommen F, de Groof AJ, Fukuda H, Ohmori M, Ishihara R, Wu L, Yu H, Mori Y, Repici A, Bergman JJGHM, Sharma P, Messmann H, Hassan C, Fuccio L, Dinis-Ribeiro M. Endoscopists' diagnostic accuracy in detecting upper gastrointestinal neoplasia in the framework of artificial intelligence studies. *Endoscopy* 2022; **54**: 403-411 [PMID: 33951743 DOI: 10.1055/a-1500-3730]

30 **Pecere S**, Antonelli G, Dinis-Ribeiro M, Mori Y, Hassan C, Fuccio L, Bisschops R, Costamagna G, Jin EH, Lee D, Misawa M, Messmann H, Iacopini F, Petruzziello L, Repici A, Saito Y, Sharma P, Yamada M, Spada C, Frazzoni L. Endoscopists performance in optical diagnosis of colorectal polyps in artificial intelligence studies. *United European Gastroenterol J* 2022; **10**: 817-826 [PMID: 35984903 DOI: 10.1002/ueg2.12285]

31 **Sridhar GR**, Lakshmi G. Ethical Issues of Artificial Intelligence in Diabetes Mellitus. *Med Res Arch* 2023; **11** [DOI: 10.18103/mra.v11i8.4287]

32 **Uche-Anya E**, Anyane-Yeboa A, Berzin TM, Ghassemi M, May FP. Artificial intelligence in gastroenterology and hepatology: how to advance clinical practice while ensuring health equity. *Gut* 2022; **71**: 1909-1915 [PMID: 35688612 DOI: 10.1136/gutjnl-2021-326271]

33 **London AJ**. Artificial intelligence in medicine: Overcoming or recapitulating structural challenges to improving patient care? *Cell Rep Med* 2022; **3**: 100622 [PMID: 35584620 DOI: 10.1016/j.xcrm.2022.100622]

34 **Ghassemi M**, Birhane A, Bilal M, Kankaria S, Malone C, Mollick E, Tustumi F. ChatGPT one year on: who is using it, how and why? *Nature* 2023; **624**: 39-41 [PMID: 38036860 DOI: 10.1038/d41586-023-03798-6]

35 **Eriksen AV**, Möller S, Ryg J. Use of GPT-4 to diagnose complex clinical cases. *NEJM AI* 2023; **1**: AIp2300031 [DOI: 10.1056/aip2300031]

36 **Ashraf H**, Ashfaq H. The Role of ChatGPT in Medical Research: Progress and Limitations. *Ann Biomed Eng* 2024; **52**: 458-461 [PMID: 37452215 DOI: 10.1007/s10439-023-03311-0]

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