ISSN 2644-3236 (online)

Artificial Intelligence in *Gastroenterology*

Quarterly Volume 5 Number 2 August 8, 2024

Published by Baishideng Publishing Group Inc

Artificial Intelligence in Gastroenterology

Contents

Quarterly Volume 5 Number 2 August 8, 2024

EDITORIAL

MINIREVIEWS

Contents

Artificial Intelligence in Gastroenterology

Quarterly Volume 5 Number 2 August 8, 2024

ABOUT COVER

Editorial Board Member of *Artificial Intelligence in Gastroenterology*, Jan Grosek, MD, PhD, Assistant Professor, Surgeon, Department of Abdominal Surgery, University Medical Centre Ljubljana, Ljubljana 1000, Slovenia. jan.grosek@kclj.si

AIMS AND SCOPE

The primary aim of *Artificial Intelligence in Gastroenterology* (*AIG*, *Artif Intell Gastroenterol*) is to provide scholars and readers from various fields of artificial intelligence in gastroenterology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

AIG mainly publishes articles reporting research results obtained in the field of artificial intelligence in gastroenterology and covering a wide range of topics, including artificial intelligence in gastrointestinal cancer, liver cancer, pancreatic cancer, hepatitis B, hepatitis C, nonalcoholic fatty liver disease, inflammatory bowel disease, irritable bowel syndrome, and *Helicobacter pylori* infection.

INDEXING/ABSTRACTING

The *AIG* is now abstracted and indexed in Reference Citation Analysis, China Science and Technology Journal Database.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: *Yu-Qing Zhao*; **Production Department Director:** *Xu Guo*; **Cover Editor:** *Jin-Lei Wang*.

NAME OF JOURNAL
Artificial Intelligence in Gastroenterology

ISSN
ISSN 2644-3236 (online)

LAUNCH DATE
July 28, 2020

FREQUENCY
Quarterly

EDITORS-IN-CHIEF
Rajvinder Singh, Ferruccio Bonino

EDITORIAL BOARD MEMBERS
https://www.wjgnet.com/2644-3236/editorialboard.htm

PUBLICATION DATE
August 8, 2024

COPYRIGHT
© 2024 Baishideng Publishing Group Inc

INSTRUCTIONS TO AUTHORS
https://www.wjgnet.com/bpg/gerinfo/204

GUIDELINES FOR ETHICS DOCUMENTS
https://www.wjgnet.com/bpg/GerInfo/287

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH
https://www.wjgnet.com/bpg/gerinfo/240

PUBLICATION ETHICS
https://www.wjgnet.com/bpg/GerInfo/288

PUBLICATION MISCONDUCT
https://www.wjgnet.com/bpg/gerinfo/208

ARTICLE PROCESSING CHARGE
https://www.wjgnet.com/bpg/gerinfo/242

STEPS FOR SUBMITTING MANUSCRIPTS
https://www.wjgnet.com/bpg/GerInfo/239

ONLINE SUBMISSION
https://www.f6publishing.com

E-mail: office@baishideng.com https://www.wjgnet.com

A I G Artificial Intelligence in Gastroenterology

Submit a Manuscript: https://www.f6publishing.com

Artif Intell Gastroenterol 2024 August 8; 5(2): 91336

DOI: 10.35712/aig.v5.i2.91336

ISSN 2644-3236 (online)

EDITORIAL

Will artificial intelligence reach any limit in gastroenterology?

Joseph Bou Jaoude, Rose Al Bacha, Bassam Abboud

Specialty type: Gastroenterology and hepatology

Provenance and peer review: Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification
Scientific Quality: Grade C
Novelty: Grade C
Creativity or Innovation: Grade C
Scientific Significance: Grade C

P-Reviewer: Yu HG, China

Received: December 27, 2023
Revised: April 25, 2024
Accepted: June 7, 2024
Published online: August 8, 2024
Processing time: 225 Days and 1.4 Hours

Joseph Bou Jaoude, Rose Al Bacha, Department of Gastroenterology, Levant Hospital, Beirut 166830, Lebanon

Bassam Abboud, Department of General Surgery, Geitaoui Hospital, Faculty of Medicine, Lebanese University, Lebanon, Beirut 166830, Lebanon

Corresponding author: Bassam Abboud, MD, Professor, Department of General Surgery, Geitaoui Hospital, Faculty of Medicine, Lebanese University, Lebanon, Rmeil, Beirut 166830, Lebanon. dbabboud@yahoo.fr

Abstract

Endoscopy is the cornerstone in the management of digestive diseases. Over the last few decades, technology has played an important role in the development of this field, helping endoscopists in better detecting and characterizing luminal lesions. However, despite ongoing advancements in endoscopic technology, the incidence of missed pre-neoplastic and neoplastic lesions remains high due to the operator-dependent nature of endoscopy and the challenging learning curve associated with new technologies. Artificial intelligence (AI), an operator-independent field, could be an invaluable solution. AI can serve as a "second observer", enhancing the performance of endoscopists in detecting and characterizing luminal lesions. By utilizing deep learning (DL), an innovation within machine learning, AI automatically extracts input features from targeted endoscopic images. DL encompasses both computer-aided detection and computer-aided diagnosis, assisting endoscopists in reducing missed detection rates and predicting the histology of luminal digestive lesions. AI applications in clinical gastrointestinal diseases are continuously expanding and evolving the entire digestive tract. In all published studies, real-time AI assists endoscopists in improving the performance of non-expert gastroenterologists, bringing it to a level comparable to that of experts. The development of DL may be affected by selection biases. Studies have utilized different AI-assisted models, which are heterogeneous. In the future, algorithms need validation through large, randomized trials. Theoretically, AI has no limit to assist endoscopists in increasing the accuracy and the quality of endoscopic exams. However, practically, we still have a long way to go before standardizing our AI models to be accepted and applied by all gastroenterologists.

Key Words: Artificial intelligence; Digestive tract; Gastroenterology; Gastroscopy; Colonoscopy

Core Tip: The field of gastrointestinal endoscopy is an essential tool in the management of digestive diseases. Despite ongoing advancements in endoscopic technology, the incidence of missed pre-neoplastic and neoplastic lesions remains high. This is attributed to the operator-dependent nature of endoscopy, resulting in variability in detection rates and the characterization of lesions among endoscopists. To enhance endoscopic performance, it is imperative to minimize the "cognitive errors" made by the endoscopist. Artificial Intelligence, being operator-independent, could potentially serve as an unlimited solution.

Citation: Bou Jaoude J, Al Bacha R, Abboud B. Will artificial intelligence reach any limit in gastroenterology? *Artif Intell Gastroenterol* 2024; 5(2): 91336

URL: https://www.wjgnet.com/2644-3236/full/v5/i2/91336.htm

DOI: https://dx.doi.org/10.35712/aig.v5.i2.91336

INTRODUCTION

The field of gastrointestinal (GI) endoscopy (GE) is an essential tool in the management of digestive diseases. Technology is essential for the advancement of endoscopy. Presently, white-light endoscopy (WLE) with high resolution stands as the standard technology that enables endoscopists to detect and characterize lesions more accurately. However, despite this, even expert endoscopists can overlook several lesions, including small and flat ones.

To morphologically predict the malignant potential of digestive lesions in real-time, several classification systems have been endorsed by scientific societies. These systems categorize lesions based on morphology (sessile, slightly raised, or excavated) or through a detailed examination of vascular and mucosal patterns using optical image-enhancing technology known as virtual chromo-endoscopy. Consequently, the assessment of invasion depth or lymph node involvement plays a crucial role in clinical decision-making, determining whether the lesion is surgically or endoscopically resectable.

Despite the ongoing development of endoscopic technology, the incidence of missed pre-neoplastic and neoplastic lesions remains high. This is attributed to the operator-dependent nature of endoscopy, resulting in variability in detection rates and the characterization of lesions among endoscopists. The existence of this skills gap can be explained by the extended learning curve associated with adopting new technologies.

To enhance the performance of the endoscopic procedure, it is imperative to minimize the "cognitive errors" made by the endoscopist. Artificial intelligence (AI), being operator-independent, could potentially serve as an unlimited solution.

As endoscopy fundamentally depends on high-quality images, it presents an appealing domain for AI, which comprises computer processes performing complex tasks to simulate the human brain. Alan Turing, one of AI’s founders, defined = itas "the ability of a computer to achieve human performance in cognitive tasks". Thus, this concept combined the fields of medical knowledge and machine tools. Deep learning (DL) was innovated as a major transformation of machine learning (ML), allowing machines to learn and make decisions independently. DL automatically extracts input features from targeted images, demonstrating the ability to explore all pixels without experiencing transitory lapses in attention or fatigue. As a result, DL emerges as a promising technology, serving as a reliable "second observer" independent of the endoscopist's performance. DL encompasses two primary tasks: real-time detection or computer-aided detection (CADe) and real-time characterization or computer-aided diagnosis (CADx). Given that navigation software enhances mucosal exposure, CADe assists endoscopists in reducing the miss rate of lesion detection. Simultaneously, CADx aims to predict the histologic and optical diagnosis of pre-neoplastic lesions without the need for biopsy, as well as estimating the depth of invasion in malignant lesions to facilitate optimal therapeutic decision-making.

Moreover, DL can reduce the cost and the procedure time by abandoning random biopsies in favor of targeted ones and avoiding unnecessary resection of non-neoplastic lesions. DL can also evaluate the quality of endoscopic procedures by identifying parameters such as land marks, blind spots, measurement of withdrawal speed and mucosal cleansing assessment, making surveillance protocols more effective.

Thus, AI allows human-machine interaction, transferring expert knowledge to the entire gastroenterological community.

AI APPLICATIONS IN DIAGNOSTIC GE

AI applications in clinical GI diseases are continuously expanding and evolving into new areas. AI is embraced for its robust self-learning capability and unbiased nature. Real-time AI assists endoscopists throughout the entire digestive tract, including the upper, middle, and lower parts, as well as the hepato-biliary tree and pancreatic gland.

LOWER GI TRACT

Colorectal polyps

In the GI field, the primary application of AI involves DL convolution neural network (CNN) models for detecting and diagnosing polyps during colonoscopy.

Detection of colorectal polyps using CADe: It has been established that the removal of pre-neoplastic polyps reduces the risk of colorectal cancer (CRC). However, endoscopy is operator-dependent, and the adenoma detection rate (ADR) varies widely from 7% to 53% among colonoscopists[1] while post-colonoscopy interval CRC constitutes nearly 8% of all diagnosed CRC[2]. The initial application of AI technology in GE was the detection of colorectal polyps, with most research focusing on the management of colorectal polyps. In 2018, Urban *et al*[3]and Misawa *et al*[4] reported the two earliest applications of CADe on video clips. Their algorithms demonstrated an accuracy of ≥90%. In 2019, Wang *et al*[5] conducted the first randomized controlled trial. Since then, numerous prospective randomized controlled trials[6-10], as well as meta-analyses[11], have been published, involving different AI systems and training. Consequently, CADe for polyp detection has been shown to increase the ADR, at least comparable to that assessed by experienced endoscopists, as recommended by the European Society of Gastrointestinal Endoscopy (ESGE) guidelines[12].

Characterization of colorectal polyps using CADx (polyp ≤ 5 mm): According to the current ESGE guidelines, polyps ≤ 5 mm with adenomatous structures need to be removed and sent for histopathological analysis. Diminutive polyps located in the recto-sigmoid, characterized as hyperplastic by virtual chromo-endoscopy, can either be "left in situ" or undergo the "resect and discard" approach. CADx tools, when combined with CADe, can assist endoscopists in real-time colonoscopy by distinguishing between neoplastic (adenoma or serrated) and non-neoplastic (hyperplastic) polyps. Consequently, in the case of non-neoplastic polyps, the "diagnose and leave" strategy reduces the need for polypectomy. Similarly, for neoplastic diminutive polyps, the "resect and discard" strategy minimizes the necessity for histopathological processing. In clinical practice, these two strategies, supported by CADe systems, contribute to reduced costs and procedure time. Indeed, many centers have developed CADx tools with WLE, narrow-band imaging (NBI), and endocystoscopy[13-15]. Their published results align with the parameters outlined by the American Society of Gastrointestinal Endoscopy Preservation and Incorporation of Valuable Endoscopic Innovation (PIVI).

Advanced subtle neoplastic (flat and serrated)

The increased detection of non-advanced adenomas alone cannot reduce the interval CRC. Consequently, developing AI systems to enhance the detection of advanced polyps is now considered a priority, as they pose the highest risk of developing CRC. Most CADx studies lack data about sessile serrated lesions (SSL) and flat polyps. When SSL are des-cribed, the majority is located in the recto-sigmoid and is diminutive. Only one recent prospective study, utilizing video datasets enriched with flat, SSL, and advanced colorectal polyps, evaluated AI performance against endoscopists. The AI-based algorithm achieves high per-polyp sensitivities for the diagnosis of advanced polyps[16].

Malignancy in colorectal polyps

Endoscopists must assess the level of submucosal invasion in T1 CRC without resorting to biopsy to decide whether to perform endoscopic or surgical resection. AI emerges as an ideal tool to offer valuable guidance to endoscopists. Two Japanese AI studies were conducted using CNN algorithms to differentiate between T1a and T1b. The initial study was a randomized one and achieved 94% of accuracy; however, the second one ranged only 81.4% of accuracy[17,18].

Computer-aided quality assessment of colonoscopy technique: AI, functioning as a virtual endoscopist, can complement the expertise of endoscopists in reducing the rate of missed polyps visible on the screen. However, the quality of a colonoscopy procedure relies on additional parameters such as incomplete mucosal exposure, blind spots, withdrawal speed, and the degree of bowel cleansing. Currently, AI is developing new systems to measure these parameters during the procedure, alongside CADe and CADx, to address exposure errors. Consequently, computer-aided quality assessment objectively evaluates the time spent exploring different segments of the colon, the quality of fold examination, and mucosal cleansing[19]. Therefore, in the future, we can objectively determine the quality of colonoscopy for the optimal surveillance protocol of CRC.

UPPER GI TRACT

Esophagus

In a recent multicenter study of upper GI endoscopies, a 6.4% esophageal cancer miss rate was reported[20]. Due to the capability of DL to explore images beyond the reach of the human eye, it has been employed in the analysis of endoscopic images related to esophageal and stomach diseases. Wu *et al*[21] utilized a DL model and demonstrated promising outcomes in the classification and segmentation of individual esophageal lesions. Consequently, several CADe systems have been recently tested in clinical settings.

Precursor lesion of esophageal squamous cell neoplasia: Intrapapillary capillary loops (IPCL) observed through virtual chromoendoscopy (NBI) have been classified as a precancerous lesion of esophageal squamous cell neoplasia (ESCC), correlating with depth invasion. Everson *et al*[22] demonstrated that a DL model was an efficient, accurate, and reliable tool for classifying IPCL patterns as normal or abnormal. In two separate studies, Zhao *et al*[23] and Yuan *et al*[24] compared the accuracy of AI systems to that of endoscopists. AI models significantly enhance the ability of junior endoscopists to diagnose IPCL abnormalities and depth invasion of ESCC.

ESCC: A recent literature review demonstrated high diagnostic accuracy for AI in ESCC[25]. Extensive datasets have supported the overall diagnostic performance of AI for both superficial and advanced esophageal squamous cancer. Numerous studies have indicated that, AI accuracy in detection was comparable to or even higher than that experienced endoscopists[26-28]. In therapeutic decisions for ESCC, which depend on the depth of invasion, Zhang *et al*[29] conducted a multicenter study using an AI-based CADx model that simulated radiologists' diagnoses of lymph node metastasis. The results from AI systems significantly outperformed those of human diagnostics. Additionally, Tokai *et al*[30] published a comparative study between a DL CNN model and endoscopists to determine ESCC depth invasion. The results demonstrated that AI algorithms surpassed the performance of all endoscopists. Given these promising results, AI-assisted diagnostic techniques should be considered for adoption in future clinical practice.

Barrett’s esophagus-related neoplasia: It is established that Barrett's esophagus (BE) is a precursor of esophageal adenocarcinoma (EAC). BE represents an exemplary application of AI systems, showcasing their capability in lesion identification and determining the degree of malignancy. Pan *et al*[31] demonstrated the ability of an AI model in identifying and classifying BE according to the Prague classification. To enable endoscopists to successfully detect dysplasia or EAC in BE, several AI studies have achieved high sensitivity, specificity, and accuracy, meeting the parameters outlined by the PIVI[32-35]. Two meta-analyses have reached similar conclusions[36,37].

To choose the optimal treatment, the identification of sub-mucosal invasion of BE-related neoplasia is mandatory. A retrospective multicenter study evaluated the performance of DL algorithms in discriminating between T1a and T1b cancer[38]. The AI model demonstrated comparable performance to experienced endoscopists.

Stomach

Gastric precancerous lesions: *Helicobacter pylori* (HP) infection can produce chronic atrophic gastritis (CAG) and gastric intestinal metaplasia (GIM). CAG and GIM are precancerous lesions associated with an increased risk of gastric cancer (GC) development[39]. Thus, endoscopic surveillance of the precancerous lesions is mandatory to detect GC in an early stage, termed early GC (EGC). The diagnosis of EGC is difficult because the sensitivity of endoscopic diagnosis of CAG is only 42% in a large study and the overall rate of missed neoplasia at endoscopy varies between 8.3% and 10%[40].

AI models may improve the diagnostic accuracy and aid the endoscopist in the detection and staging of precancerous lesions.

AI in the detection of gastric precancerous lesions and HP infection: Regarding CAG, in two studies, AI models were compared to endoscopists. Zhang *et al*[41] used the CNN model to detect CAG in 1699 patients. It outperformed three expert endoscopists with a sensitivity, specificity, and accuracy of 95%, 94%, and 94% respectively. Guimaraes *et al*[42] reported a 93% accuracy with WLE images.

Concerning GIM, Yan *et al*[43] developed a CNN-CAD model with ME-NBI. It reached an accuracy of 89% compared to 84% accuracy for expert endoscopists.

Concerning HP infection, Zheng *et al*[44] developed a CADe system to detect HP infection status based on endoscopic images without the need for biopsies. The CNN systems reached an accuracy of 92%. Nakashima *et al*[45] used a DL model with WLE and blue light imaging (BLI). The DL model had an area under the curve (AUC) of 0.96 with BLI, and 0.66 with WLE.

AI in the detection of EGC: Li *et al*[46] developed a CNN model on images of benign lesions and EGC. The AI model has a diagnostic accuracy of 91% compared to an accuracy of 87% when used by experts and 70%-74% for non-expert endoscopists. Horiuchi *et al*[47] used a CADe system to detect EGC using NBI videos and compared to 11 expert endoscopists in NBI. Only two endoscopists were outperformed by the CADe systems.

AI in the prediction of invasion depth of EGC: Nagao *et al*[48] developed a CNN-CAD system by using images of GC that underwent endoscopic resection or radical surgery to evaluate the accuracy of AI to determine invasion depth. They found that the CADe system can predict the invasion depth with a sensitivity of 75%-84%, specificity of 80%-99%, and accuracy of 94% during WLE and NBI images, respectively. Yoon *et al*[49] analyzed images of GC (T1a and T1b) to predict invasion depth with AUC of 0.85. This accuracy was significantly lower in undifferentiated lesions.

SMALL BOWEL

Inflammatory bowel disease

Recently, the therapeutic goals for patients with inflammatory bowel disease (IBD) have shifted toward mucosal healing, defined by endoscopic evaluation. However, histologic evaluation is essential to predict the risk of relapse and colon cancer.

This GI field has emerged as a new area for AI, utilizing data from endoscopic images, video capsule endoscopy images, histology, magnetic resonance imaging images, laboratory studies, and genetics. Numerous studies with meta-analyses using ML and DL systems have aimed to detect Crohn's disease and ulcerative colitis with high sensitivity and accuracy[49]. Additionally, AI studies utilizing ML and DL CNN systems have achieved a high level of accuracy in predicting disease severity for IBD[50,51].

Villous atrophy

Celiac disease is the primary cause of villous atrophy and remains undiagnosed in 50% of cases. A study conducted by Gadermayr *et al*[52] achieved a high accuracy of 94%, but that requires water immersion. Also, studies with video capsule endoscopy showed an accuracy > 90%[52-54]. These studies were conducted under special conditions with high probability of suspicion. It is mandatory to make the diagnosis in routine endoscopy. A recent retrospective study done by Scheppach *et al*[55] compared AI algorithms to performance of fellows and experts on routine endoscopy. The results showed that AI significantly improved the performance of all endoscopists with stable performance.

PANCREAS

Endoscopic ultrasound (EUS) is a reliable tool for the detection and staging of pancreatic lesions, particularly pancreatic cancer (PC). EUS-FNB is a well-established diagnostic tool for PC, demonstrating a specificity and sensitivity greater than 90%. However, the EUS technique is operator-dependent, exhibiting inter-observer variability, making it an ideal platform for AI applications.

AI in EUS for detection of PC

Three retrospective studies were conducted using DL algorithms, demonstrating high sensitivity, specificity, and accuracy in diagnosing PC[56-58]. Additionally, Goyal *et al*[59] conducted a systematic review of 11 studies on the role of AI-assisted EUS models in diagnosing PC, revealing that AI algorithms had high potential for detecting PC.

AI in EUS differentiation PC from benign lesions

Chronic pancreatitis: Chronic pancreatitis still mimics PC in radiologic features and is also considered a risk factor for the development of PC. Five studies were conducted with DL algorithms, reporting high accuracy, sensitivity, and specificity [60-64]. However, these studies were heterogeneous with a small patient population. Hence, two recent prospective multicenter studies using DL models were published, validating the aforementioned findings[65,66]. Therefore, AI-assisted EUS can be a validated tool in clinical practice to differentiate PC from chronic pancreatitis with accepted results.

Autoimmune pancreatitis: Marya *et al*[67] conducted a unique study using a DL model to differentiate between PC and autoimmune pancreatitis. The high sensitivity and specificity encourage the use of AI to assist EUS endoscopists in this field.

LIMITATIONS

Input data

DL tasks rely on databases used to train AI algorithms, which must be manually annotated and propagated through frames using dedicated software. The development of DL may be affected by selection biases, which include the chosen disease, its prevalence, the endoscopic center's characteristics, the patient population, and the number of patients enrolled. Spectrum biases in DL performance can arise from variations in patient population, the number and skills of endoscopists, and the technical characteristics used, such as WLE, advanced imaging, and optical magnification. Consequently, a database from a single institution, lacking diversity and failing to capture all possible variations, can impact the quality of input data, as well as the reproducibility and generalizability of the results. To mitigate these biases, it is essential to establish a quality-monitored central data collection server that aggregates data from all institutions.

Algorithm

Studies utilize different AI-assisted models that require images prepared in specific ways. These algorithms may not consistently achieve a high degree of accuracy. Therefore, it is essential to establish a universal protocol for input data to enhance the efficacy and accuracy of AI-assisted models.

Validation

AI findings must undergo clinical validation before being introduced into clinical practice. AI has a valuable advantage when the reference standard is based on histologic verification. However, if not, the reference standard relies on expert endoscopist raters, introducing potential bias. Therefore, AI systems should be validated through randomized trials comparing the standard and new endoscopic modalities. Additionally, these algorithms must be tested on large and cross-institutional datasets. Long-term data on the accuracy of AI-assisted models is lacking. Consequently, there are no results regarding the impact of AI on reducing the incidence and mortality of GI cancer. Clinical efficacy evaluation must adhere to established guidelines. The two recommended guidelines are the PIVI statement as a guide for new imaging technology and the ESGE guidelines. For example, in cases requiring targeted biopsies, PIVI recommends a per-patient sensitivity of 90% or greater and a specificity of 80% or greater to allow a reduction in biopsies. Therefore, studies must meet these parameters to be approved for clinical practice. Additionally, according to ESGE, the results of AI studies must be comparable to those of experts.

Output

There are "black boxes" in the logic of DL algorithm decision-making processes that are not understood or controlled by humans[68]. Consequently, AI can make mistakes, and humans cannot explain or justify the computer's decisions. For instance, physicians have concerns regarding the number of false-positive signals generated by AI. This may cause distraction, prolong procedure time, and frustrate the endoscopist, making some users hesitant to use it. Therefore, humans must make the final decision and should not become entirely dependent on AI technology for both diagnostic and therapeutic endoscopies; otherwise, they risk losing their cognitive abilities.

CONCLUSION

In conclusion, because the GI field relies on imaging, AI-assisted algorithms continue to explore new GI organs and diseases. The growth and applications of AI increase exponentially with the development of computer science and may reach no limit. However, we must be careful about how we use it and preserve our independence in the final decision. Additionally, to achieve better results in AI studies in the future, collaboration between academic and private gastroenterologists and the industry must be closer, aiming to improve the quality, utility, ease of use, and accuracy of AI models. We hope that AI-assisted diagnostic techniques will be widely used in GI diseases because AI is an unavoidable tool in GI endoscopy.

FOOTNOTES

Author contributions: Abboud B designed the research; Bou Jaoude J and Al Bacha R performed the research; Bou Jaoude J, Al Bacha R and Abboud B analyzed the data; Bou Japude J, Al Bacha R and Abboud B wrote the paper.

Conflict-of-interest statement: The authors declare no conflicts of interest.

Country of origin: Lebanon

ORCID number: Joseph Bou Jaoude 0000-0002-9858-3309; Bassam Abboud 0000-0001-5268-2347.

S-Editor: Lin C
L-Editor: Filipodia
P-Editor: Zhao YQ

REFERENCES

1 **Corley DA**, Jensen CD, Marks AR, Zhao WK, Lee JK, Doubeni CA, Zauber AG, de Boer J, Fireman BH, Schottinger JE, Quinn VP, Ghai NR, Levin TR, Quesenberry CP. Adenoma detection rate and risk of colorectal cancer and death. *N Engl J Med* 2014; **370**: 1298-1306 [PMID: 24693890 DOI: 10.1056/NEJMoa1309086]

2 **Cooper GS**, Xu F, Barnholtz Sloan JS, Schluchter MD, Koroukian SM. Prevalence and predictors of interval colorectal cancers in medicare beneficiaries. *Cancer* 2012; **118**: 3044-3052 [PMID: 21989586 DOI: 10.1002/cncr.26602]

3 **Urban G**, Tripathi P, Alkayali T, Mittal M, Jalali F, Karnes W, Baldi P. Deep Learning Localizes and Identifies Polyps in Real Time With 96% Accuracy in Screening Colonoscopy. *Gastroenterology* 2018; **155**: 1069-1078.e8 [PMID: 29928897 DOI: 10.1053/j.gastro.2018.06.037]

4 **Misawa M**, Kudo SE, Mori Y, Cho T, Kataoka S, Yamauchi A, Ogawa Y, Maeda Y, Takeda K, Ichimasa K, Nakamura H, Yagawa Y, Toyoshima N, Ogata N, Kudo T, Hisayuki T, Hayashi T, Wakamura K, Baba T, Ishida F, Itoh H, Roth H, Oda M, Mori K. Artificial Intelligence-Assisted Polyp Detection for Colonoscopy: Initial Experience. *Gastroenterology* 2018; **154**: 2027-2029.e3 [PMID: 29653147 DOI: 10.1053/j.gastro.2018.04.003]

5 **Wang P**, Berzin TM, Glissen Brown JR, Bharadwaj S, Becq A, Xiao X, Liu P, Li L, Song Y, Zhang D, Li Y, Xu G, Tu M, Liu X. Real-time automatic detection system increases colonoscopic polyp and adenoma detection rates: a prospective randomised controlled study. *Gut* 2019; **68**: 1813-1819 [PMID: 30814121 DOI: 10.1136/gutjnl-2018-317500]

6 **Xu H**, Tang RSY, Lam TYT, Zhao G, Lau JYW, Liu Y, Wu Q, Rong L, Xu W, Li X, Wong SH, Cai S, Wang J, Liu G, Ma T, Liang X, Mak JWY, Xu H, Yuan P, Cao T, Li F, Ye Z, Shutian Z, Sung JJY. Artificial Intelligence-Assisted Colonoscopy for Colorectal Cancer Screening: A Multicenter Randomized Controlled Trial. *Clin Gastroenterol Hepatol* 2023; **21**: 337-346.e3 [PMID: 35863686 DOI: 10.1016/j.cgh.2022.07.006]

7 **Nehme F**, Coronel E, Barringer DA, Romero LG, Shafi MA, Ross WA, Ge PS. Performance and attitudes toward real-time computer-aided polyp detection during colonoscopy in a large tertiary referral center in the United States. *Gastrointest Endosc* 2023; **98**: 100-109.e6 [PMID: 36801459 DOI: 10.1016/j.gie.2023.02.016]

8 **Shaukat A**, Lichtenstein DR, Somers SC, Chung DC, Perdue DG, Gopal M, Colucci DR, Phillips SA, Marka NA, Church TR, Brugge WR;

SKOUT™ Registration Study Team. Computer-Aided Detection Improves Adenomas per Colonoscopy for Screening and Surveillance Colonoscopy: A Randomized Trial. *Gastroenterology* 2022; **163**: 732-741 [PMID: 35643173 DOI: 10.1053/j.gastro.2022.05.028]

9 **Wallace MB**, Sharma P, Bhandari P, East J, Antonelli G, Lorenzetti R, Vieth M, Speranza I, Spadaccini M, Desai M, Lukens FJ, Babameto G, Batista D, Singh D, Palmer W, Ramirez F, Palmer R, Lunsford T, Ruff K, Bird-Liebermann E, Ciofoaia V, Arndtz S, Cangemi D, Puddick K, Derfus G, Johal AS, Barawi M, Longo L, Moro L, Repici A, Hassan C. Impact of Artificial Intelligence on Miss Rate of Colorectal Neoplasia. *Gastroenterology* 2022; **163**: 295-304.e5 [PMID: 35304117 DOI: 10.1053/j.gastro.2022.03.007]

10 **Glissen Brown JR**, Mansour NM, Wang P, Chuchuca MA, Minchenberg SB, Chandnani M, Liu L, Gross SA, Sengupta N, Berzin TM. Deep Learning Computer-aided Polyp Detection Reduces Adenoma Miss Rate: A United States Multi-center Randomized Tandem Colonoscopy Study (CADeT-CS Trial). *Clin Gastroenterol Hepatol* 2022; **20**: 1499-1507.e4 [PMID: 34530161 DOI: 10.1016/j.cgh.2021.09.009]

11 **Hassan C**, Spadaccini M, Iannone A, Maselli R, Jovani M, Chandrasekar VT, Antonelli G, Yu H, Areia M, Dinis-Ribeiro M, Bhandari P, Sharma P, Rex DK, Rösch T, Wallace M, Repici A. Performance of artificial intelligence in colonoscopy for adenoma and polyp detection: a systematic review and meta-analysis. *Gastrointest Endosc* 2021; **93**: 77-85.e6 [PMID: 32598963 DOI: 10.1016/j.gie.2020.06.059]

12 **Messmann H**, Bisschops R, Antonelli G, Libânio D, Sinonquel P, Abdelrahim M, Ahmad OF, Areia M, Bergman JJGHM, Bhandari P, Boskoski I, Dekker E, Domagk D, Ebigbo A, Eelbode T, Eliakim R, Häfner M, Haidry RJ, Jover R, Kaminski MF, Kuvaev R, Mori Y, Palazzo M, Repici A, Rondonotti E, Rutter MD, Saito Y, Sharma P, Spada C, Spadaccini M, Veitch A, Gralnek IM, Hassan C, Dinis-Ribeiro M. Expected value of artificial intelligence in gastrointestinal endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) Position Statement. *Endoscopy* 2022; **54**: 1211-1231 [PMID: 36270318 DOI: 10.1055/a-1950-5694]

13 **Mori Y**, Kudo SE, Misawa M, Saito Y, Ikematsu H, Hotta K, Ohtsuka K, Urushibara F, Kataoka S, Ogawa Y, Maeda Y, Takeda K, Nakamura H, Ichimasa K, Kudo T, Hayashi T, Wakamura K, Ishida F, Inoue H, Itoh H, Oda M, Mori K. Real-Time Use of Artificial Intelligence in Identification of Diminutive Polyps During Colonoscopy: A Prospective Study. *Ann Intern Med* 2018; **169**: 357-366 [PMID: 30105375 DOI: 10.7326/M18-0249]

14 **Rondonotti E**, Hassan C, Tamanini G, Antonelli G, Andrisani G, Leonetti G, Paggi S, Amato A, Scardino G, Di Paolo D, Mandelli G, Lenoci N, Terreni N, Andrealli A, Maselli R, Spadaccini M, Galtieri PA, Correale L, Repici A, Di Matteo FM, Ambrosiani L, Filippi E, Sharma P, Radaelli F. Artificial intelligence-assisted optical diagnosis for the resect-and-discard strategy in clinical practice: the Artificial intelligence BLI Characterization (ABC) study. *Endoscopy* 2023; **55**: 14-22 [PMID: 35562098 DOI: 10.1055/a-1852-0330]

15 **Hassan C**, Balsamo G, Lorenzetti R, Zullo A, Antonelli G. Artificial Intelligence Allows Leaving-In-Situ Colorectal Polyps. *Clin Gastroenterol Hepatol* 2022; **20**: 2505-2513.e4 [PMID: 35835342 DOI: 10.1016/j.cgh.2022.04.045]

16 **Ahmad OF**, González-Bueno Puyal J, Brandao P, Kader R, Abbasi F, Hussein M, Haidry RJ, Toth D, Mountney P, Seward E, Vega R, Stoyanov D, Lovat LB. Performance of artificial intelligence for detection of subtle and advanced colorectal neoplasia. *Dig Endosc* 2022; **34**: 862-869 [PMID: 34748665 DOI: 10.1111/den.14187]

17 **Takeda K**, Kudo SE, Mori Y, Misawa M, Kudo T, Wakamura K, Katagiri A, Baba T, Hidaka E, Ishida F, Inoue H, Oda M, Mori K. Accuracy of diagnosing invasive colorectal cancer using computer-aided endocytoscopy. *Endoscopy* 2017; **49**: 798-802 [PMID: 28472832 DOI: 10.1055/s-0043-105486]

18 **Ito N**, Kawahira H, Nakashima H, Uesato M, Miyauchi H, Matsubara H. Endoscopic Diagnostic Support System for cT1b Colorectal Cancer Using Deep Learning. *Oncology* 2019; **96**: 44-50 [PMID: 30130758 DOI: 10.1159/000491636]

19 **Liu W**, Wu Y, Yuan X, Zhang J, Zhou Y, Zhang W, Zhu P, Tao Z, He L, Hu B, Yi Z. Artificial intelligence-based assessments of colonoscopic withdrawal technique: a new method for measuring and enhancing the quality of fold examination. *Endoscopy* 2022; **54**: 972-979 [PMID: 35391493 DOI: 10.1055/a-1799-8297]

20 **Rodríguez de Santiago E**, Hernanz N, Marcos-Prieto HM, De-Jorge-Turrión MÁ, Barreiro-Alonso E, Rodríguez-Escaja C, Jiménez-Jurado A, Sierra-Morales M, Pérez-Valle I, Machado-Volpato N, García-Prada M, Núñez-Gómez L, Castaño-García A, García García de Paredes A, Peñas B, Vázquez-Sequeiros E, Albillos A. Rate of missed oesophageal cancer at routine endoscopy and survival outcomes: A multicentric cohort study. *United European Gastroenterol J* 2019; **7**: 189-198 [PMID: 31080603 DOI: 10.1177/2050640618811477]

21 **Wu Z**, Ge R, Wen M, Liu G, Chen Y, Zhang P, He X, Hua J, Luo L, Li S. ELNet:Automatic classification and segmentation for esophageal lesions using convolutional neural network. *Med Image Anal* 2021; **67**: 101838 [PMID: 33129148 DOI: 10.1016/j.media.2020.101838]

22 **Everson M**, Herrera L, Li W, Luengo IM, Ahmad O, Banks M, Magee C, Alzoubaidi D, Hsu HM, Graham D, Vercauteren T, Lovat L, Ourselin S, Kashin S, Wang HP, Wang WL, Haidry RJ. Artificial intelligence for the real-time classification of intrapapillary capillary loop patterns in the endoscopic diagnosis of early oesophageal squamous cell carcinoma: A proof-of-concept study. *United European Gastroenterol J* 2019; **7**: 297-306 [PMID: 31080614 DOI: 10.1177/2050640618821800]

23 **Zhao YY**, Xue DX, Wang YL, Zhang R, Sun B, Cai YP, Feng H, Cai Y, Xu JM. Computer-assisted diagnosis of early esophageal squamous cell carcinoma using narrow-band imaging magnifying endoscopy. *Endoscopy* 2019; **51**: 333-341 [PMID: 30469155 DOI: 10.1055/a-0756-8754]

24 **Yuan XL**, Liu W, Liu Y, Zeng XH, Mou Y, Wu CC, Ye LS, Zhang YH, He L, Feng J, Zhang WH, Wang J, Chen X, Hu YX, Zhang KH, Hu B. Artificial intelligence for diagnosing microvessels of precancerous lesions and superficial esophageal squamous cell carcinomas: a multicenter study. *Surg Endosc* 2022; **36**: 8651-8662 [PMID: 35705757 DOI: 10.1007/s00464-022-09353-0]

25 **Liu DY**, Gan T, Rao NN, Xing YW, Zheng J, Li S, Luo CS, Zhou ZJ, Wan YL. Identification of lesion images from gastrointestinal endoscope based on feature extraction of combinational methods with and without learning process. *Med Image Anal* 2016; **32**: 281-294 [PMID: 27236223 DOI: 10.1016/j.media.2016.04.007]

26 **Horie Y**, Yoshio T, Aoyama K, Yoshimizu S, Horiuchi Y, Ishiyama A, Hirasawa T, Tsuchida T, Ozawa T, Ishihara S, Kumagai Y, Fujishiro M, Maetani I, Fujisaki J, Tada T. Diagnostic outcomes of esophageal cancer by artificial intelligence using convolutional neural networks. *Gastrointest Endosc* 2019; **89**: 25-32 [PMID: 30120958 DOI: 10.1016/j.gie.2018.07.037]

27 **Cai SL**, Li B, Tan WM, Niu XJ, Yu HH, Yao LQ, Zhou PH, Yan B, Zhong YS. Using a deep learning system in endoscopy for screening of early esophageal squamous cell carcinoma (with video). *Gastrointest Endosc* 2019; **90**: 745-753.e2 [PMID: 31302091 DOI: 10.1016/j.gie.2019.06.044]

28 **Zhang YH**, Guo LJ, Yuan XL, Hu B. Artificial intelligence-assisted esophageal cancer management: Now and future. *World J Gastroenterol* 2020; **26**: 5256-5271 [PMID: 32994686 DOI: 10.3748/wjg.v26.i35.5256]

29 **Zhang ST**, Wang SY, Zhang J, Dong D, Mu W, Xia XE, Fu FF, Lu YN, Wang S, Tang ZC, Li P, Qu JR, Wang MY, Tian J, Liu JH. Artificial intelligence-based computer-aided diagnosis system supports diagnosis of lymph node metastasis in esophageal squamous cell carcinoma: A multicenter study. *Heliyon* 2023; **9**: e14030 [PMID: 36923854 DOI: 10.1016/j.heliyon.2023.e14030]

30 **Tokai Y**, Yoshio T, Aoyama K, Horie Y, Yoshimizu S, Horiuchi Y, Ishiyama A, Tsuchida T, Hirasawa T, Sakakibara Y, Yamada T,

Yamaguchi S, Fujisaki J, Tada T. Application of artificial intelligence using convolutional neural networks in determining the invasion depth of esophageal squamous cell carcinoma. *Esophagus* 2020; **17**: 250-256 [PMID: 31980977 DOI: 10.1007/s10388-020-00716-x]

31 **Pan W**, Li X, Wang W, Zhou L, Wu J, Ren T, Liu C, Lv M, Su S, Tang Y. Identification of Barrett's esophagus in endoscopic images using deep learning. *BMC Gastroenterol* 2021; **21**: 479 [PMID: 34920705 DOI: 10.1186/s12876-021-02055-2]

32 **Ebigbo A**, Mendel R, Probst A, Manzeneder J, Prinz F, de Souza LA Jr, Papa J, Palm C, Messmann H. Real-time use of artificial intelligence in the evaluation of cancer in Barrett's oesophagus. *Gut* 2020; **69**: 615-616 [PMID: 31541004 DOI: 10.1136/gutjnl-2019-319460]

33 **de Groof AJ**, Struyvenberg MR, van der Putten J, van der Sommen F, Fockens KN, Curvers WL, Zinger S, Pouw RE, Coron E, Baldaque-Silva F, Pech O, Weusten B, Meining A, Neuhaus H, Bisschops R, Dent J, Schoon EJ, de With PH, Bergman JJ. Deep-Learning System Detects Neoplasia in Patients With Barrett's Esophagus With Higher Accuracy Than Endoscopists in a Multistep Training and Validation Study With Benchmarking. *Gastroenterology* 2020; **158**: 915-929.e4 [PMID: 31759929 DOI: 10.1053/j.gastro.2019.11.030]

34 **Abdelrahim M**, Saiko M, Maeda N, Hossain E, Alkandari A, Subramaniam S, Parra-Blanco A, Sanchez-Yague A, Coron E, Repici A, Bhandari P. Development and validation of artificial neural networks model for detection of Barrett's neoplasia: a multicenter pragmatic nonrandomized trial (with video). *Gastrointest Endosc* 2023; **97**: 422-434 [PMID: 36283443 DOI: 10.1016/j.gie.2022.10.031]

35 **Hashimoto R**, Requa J, Dao T, Ninh A, Tran E, Mai D, Lugo M, El-Hage Chehade N, Chang KJ, Karnes WE, Samarasena JB. Artificial intelligence using convolutional neural networks for real-time detection of early esophageal neoplasia in Barrett's esophagus (with video). *Gastrointest Endosc* 2020; **91**: 1264-1271.e1 [PMID: 31930967 DOI: 10.1016/j.gie.2019.12.049]

36 **Arribas J**, Antonelli G, Frazzoni L, Fuccio L, Ebigbo A, van der Sommen F, Ghatwary N, Palm C, Coimbra M, Renna F, Bergman JJGHM, Sharma P, Messmann H, Hassan C, Dinis-Ribeiro MJ. Standalone performance of artificial intelligence for upper GI neoplasia: a meta-analysis. *Gut* 2020 [PMID: 33127833 DOI: 10.1136/gutjnl-2020-321922]

37 **Tan JL**, Chinnaratha MA, Woodman R, Martin R, Chen HT, Carneiro G, Singh R. Diagnostic Accuracy of Artificial Intelligence (AI) to Detect Early Neoplasia in Barrett's Esophagus: A Non-comparative Systematic Review and Meta-Analysis. *Front Med (Lausanne)* 2022; **9**: 890720 [PMID: 35814747 DOI: 10.3389/fmed.2022.890720]

38 **Ebigbo A**, Mendel R, Rückert T, Schuster L, Probst A, Manzeneder J, Prinz F, Mende M, Steinbrück I, Faiss S, Rauber D, de Souza LA Jr, Papa JP, Deprez PH, Oyama T, Takahashi A, Seewald S, Sharma P, Byrne MF, Palm C, Messmann H. Endoscopic prediction of submucosal invasion in Barrett's cancer with the use of artificial intelligence: a pilot study. *Endoscopy* 2021; **53**: 878-883 [PMID: 33197942 DOI: 10.1055/a-1311-8570]

39 **Pimentel-Nunes P**, Libânio D, Marcos-Pinto R, Areia M, Leja M, Esposito G, Garrido M, Kikuste I, Megraud F, Matysiak-Budnik T, Annibale B, Dumonceau JM, Barros R, Fléjou JF, Carneiro F, van Hooft JE, Kuipers EJ, Dinis-Ribeiro M. Management of epithelial precancerous conditions and lesions in the stomach (MAPS II): European Society of Gastrointestinal Endoscopy (ESGE), European Helicobacter and Microbiota Study Group (EHMSG), European Society of Pathology (ESP), and Sociedade Portuguesa de Endoscopia Digestiva (SPED) guideline update 2019. *Endoscopy* 2019; **51**: 365-388 [PMID: 30841008 DOI: 10.1055/a-0859-1883]

40 **Pimenta-Melo AR**, Monteiro-Soares M, Libânio D, Dinis-Ribeiro M. Missing rate for gastric cancer during upper gastrointestinal endoscopy: a systematic review and meta-analysis. *Eur J Gastroenterol Hepatol* 2016; **28**: 1041-1049 [PMID: 27148773 DOI: 10.1097/MEG.0000000000000657]

41 **Zhang Y**, Li F, Yuan F, Zhang K, Huo L, Dong Z, Lang Y, Zhang Y, Wang M, Gao Z, Qin Z, Shen L. Diagnosing chronic atrophic gastritis by gastroscopy using artificial intelligence. *Dig Liver Dis* 2020; **52**: 566-572 [PMID: 32061504 DOI: 10.1016/j.dld.2019.12.146]

42 **Guimarães P**, Keller A, Fehlmann T, Lammert F, Casper M. Deep-learning based detection of gastric precancerous conditions. *Gut* 2020; **69**: 4-6 [PMID: 31375599 DOI: 10.1136/gutjnl-2019-319347]

43 **Yan T**, Wong PK, Choi IC, Vong CM, Yu HH. Intelligent diagnosis of gastric intestinal metaplasia based on convolutional neural network and limited number of endoscopic images. *Comput Biol Med* 2020; **126**: 104026 [PMID: 33059237 DOI: 10.1016/j.compbiomed.2020.104026]

44 **Zheng W**, Zhang X, Kim JJ, Zhu X, Ye G, Ye B, Wang J, Luo S, Li J, Yu T, Liu J, Hu W, Si J. High Accuracy of Convolutional Neural Network for Evaluation of Helicobacter pylori Infection Based on Endoscopic Images: Preliminary Experience. *Clin Transl Gastroenterol* 2019; **10**: e00109 [PMID: 31833862 DOI: 10.14309/ctg.0000000000000109]

45 **Nakashima H**, Kawahira H, Kawachi H, Sakaki N. Artificial intelligence diagnosis of Helicobacter pylori infection using blue laser imaging-bright and linked color imaging: a single-center prospective study. *Ann Gastroenterol* 2018; **31**: 462-468 [PMID: 29991891 DOI: 10.20524/aog.2018.0269]

46 **Li L**, Chen Y, Shen Z, Zhang X, Sang J, Ding Y, Yang X, Li J, Chen M, Jin C, Chen C, Yu C. Convolutional neural network for the diagnosis of early gastric cancer based on magnifying narrow band imaging. *Gastric Cancer* 2020; **23**: 126-132 [PMID: 31332619 DOI: 10.1007/s10120-019-00992-2]

47 **Horiuchi Y**, Hirasawa T, Ishizuka N, Tokai Y, Namikawa K, Yoshimizu S, Ishiyama A, Yoshio T, Tsuchida T, Fujisaki J, Tada T. Performance of a computer-aided diagnosis system in diagnosing early gastric cancer using magnifying endoscopy videos with narrow-band imaging (with videos). *Gastrointest Endosc* 2020; **92**: 856-865.e1 [PMID: 32422155 DOI: 10.1016/j.gie.2020.04.079]

48 **Nagao S**, Tsuji Y, Sakaguchi Y, Takahashi Y, Minatsuki C, Niimi K, Yamashita H, Yamamichi N, Seto Y, Tada T, Koike K. Highly accurate artificial intelligence systems to predict the invasion depth of gastric cancer: efficacy of conventional white-light imaging, nonmagnifying narrow-band imaging, and indigo-carmine dye contrast imaging. *Gastrointest Endosc* 2020; **92**: 866-873.e1 [PMID: 32592776 DOI: 10.1016/j.gie.2020.06.047]

49 **Yoon HJ**, Kim S, Kim JH, Keum JS, Oh SI, Jo J, Chun J, Youn YH, Park H, Kwon IG, Choi SH, Noh SH. A Lesion-Based Convolutional Neural Network Improves Endoscopic Detection and Depth Prediction of Early Gastric Cancer. *J Clin Med* 2019; **8** [PMID: 31454949 DOI: 10.3390/jcm8091310]

50 **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]

51 **Yao H**, Najarian K, Gryak J, Bishu S, Rice MD, Waljee AK, Wilkins HJ, Stidham RW. Fully automated endoscopic disease activity assessment in ulcerative colitis. *Gastrointest Endosc* 2021; **93**: 728-736.e1 [PMID: 32810479 DOI: 10.1016/j.gie.2020.08.011]

52 **Gadermayr M**, Kogler H, Karla M, Merhof D, Uhl A, Vécsei A. Computer-aided texture analysis combined with experts' knowledge: Improving endoscopic celiac disease diagnosis. *World J Gastroenterol* 2016; **22**: 7124-7134 [PMID: 27610022 DOI: 10.3748/wjg.v22.i31.7124]

53 **Stoleru CA**, Dulf EH, Ciobanu L. Automated detection of celiac disease using Machine Learning Algorithms. *Sci Rep* 2022; **12**: 4071 [PMID: 35260574 DOI: 10.1038/s41598-022-07199-z]

54 **Wang X**, Qian H, Ciaccio EJ, Lewis SK, Bhagat G, Green PH, Xu S, Huang L, Gao R, Liu Y. Celiac disease diagnosis from videocapsule endoscopy images with residual learning and deep feature extraction. *Comput Methods Programs Biomed* 2020; **187**: 105236 [PMID: 31786452 DOI: 10.1016/j.cmpb.2019.105236]

55 **Scheppach MW**, Rauber D, Stallhofer J, Muzalyova A, Otten V, Manzeneder C, Schwamberger T, Wanzl J, Schlottmann J, Tadic V, Probst A, Schnoy E, Römmele C, Fleischmann C, Meinikheim M, Miller S, Märkl B, Stallmach A, Palm C, Messmann H, Ebigbo A. Detection of duodenal villous atrophy on endoscopic images using a deep learning algorithm. *Gastrointest Endosc* 2023; **97**: 911-916 [PMID: 36646146 DOI: 10.1016/j.gie.2023.01.006]

56 **Kuwahara T**, Hara K, Mizuno N, Okuno N, Matsumoto S, Obata M, Kurita Y, Koda H, Toriyama K, Onishi S, Ishihara M, Tanaka T, Tajika M, Niwa Y. Usefulness of Deep Learning Analysis for the Diagnosis of Malignancy in Intraductal Papillary Mucinous Neoplasms of the Pancreas. *Clin Transl Gastroenterol* 2019; **10**: 1-8 [PMID: 31117111 DOI: 10.14309/ctg.0000000000000045]

57 **Zhang MM**, Yang H, Jin ZD, Yu JG, Cai ZY, Li ZS. Differential diagnosis of pancreatic cancer from normal tissue with digital imaging processing and pattern recognition based on a support vector machine of EUS images. *Gastrointest Endosc* 2010; **72**: 978-985 [PMID: 20855062 DOI: 10.1016/j.gie.2010.06.042]

58 **Ozkan M**, Cakiroglu M, Kocaman O, Kurt M, Yilmaz B, Can G, Korkmaz U, Dandil E, Eksi Z. Age-based computer-aided diagnosis approach for pancreatic cancer on endoscopic ultrasound images. *Endosc Ultrasound* 2016; **5**: 101-107 [PMID: 27080608 DOI: 10.4103/2303-9027.180473]

59 **Goyal H**, Sherazi SAA, Gupta S, Perisetti A, Achebe I, Ali A, Tharian B, Thosani N, Sharma NR. Application of artificial intelligence in diagnosis of pancreatic malignancies by endoscopic ultrasound: a systemic review. *Therap Adv Gastroenterol* 2022; **15**: 17562848221093873 [PMID: 35509425 DOI: 10.1177/17562848221093873]

60 **Das A**, Nguyen CC, Li F, Li B. Digital image analysis of EUS images accurately differentiates pancreatic cancer from chronic pancreatitis and normal tissue. *Gastrointest Endosc* 2008; **67**: 861-867 [PMID: 18179797 DOI: 10.1016/j.gie.2007.08.036]

61 **Norton ID**, Zheng Y, Wiersema MS, Greenleaf J, Clain JE, Dimagno EP. Neural network analysis of EUS images to differentiate between pancreatic malignancy and pancreatitis. *Gastrointest Endosc* 2001; **54**: 625-629 [PMID: 11677484 DOI: 10.1067/mge.2001.118644]

62 **Tonozuka R**, Itoi T, Nagata N, Kojima H, Sofuni A, Tsuchiya T, Ishii K, Tanaka R, Nagakawa Y, Mukai S. Deep learning analysis for the detection of pancreatic cancer on endosonographic images: a pilot study. *J Hepatobiliary Pancreat Sci* 2021; **28**: 95-104 [PMID: 32910528 DOI: 10.1002/jhbp.825]

63 **Zhu M**, Xu C, Yu J, Wu Y, Li C, Zhang M, Jin Z, Li Z. Differentiation of pancreatic cancer and chronic pancreatitis using computer-aided diagnosis of endoscopic ultrasound (EUS) images: a diagnostic test. *PLoS One* 2013; **8**: e63820 [PMID: 23704940 DOI: 10.1371/journal.pone.0063820]

64 **Săftoiu A**, Vilmann P, Dietrich CF, Iglesias-Garcia J, Hocke M, Seicean A, Ignee A, Hassan H, Streba CT, Ioncică AM, Gheonea DI, Ciurea T. Quantitative contrast-enhanced harmonic EUS in differential diagnosis of focal pancreatic masses (with videos). *Gastrointest Endosc* 2015; **82**: 59-69 [PMID: 25792386 DOI: 10.1016/j.gie.2014.11.040]

65 **Săftoiu A**, Vilmann P, Gorunescu F, Gheonea DI, Gorunescu M, Ciurea T, Popescu GL, Iordache A, Hassan H, Iordache S. Neural network analysis of dynamic sequences of EUS elastography used for the differential diagnosis of chronic pancreatitis and pancreatic cancer. *Gastrointest Endosc* 2008; **68**: 1086-1094 [PMID: 18656186 DOI: 10.1016/j.gie.2008.04.031]

66 **Săftoiu A**, Vilmann P, Gorunescu F, Janssen J, Hocke M, Larsen M, Iglesias-Garcia J, Arcidiacono P, Will U, Giovannini M, Dietrich CF, Havre R, Gheorghe C, McKay C, Gheonea DI, Ciurea T; European EUS Elastography Multicentric Study Group. Efficacy of an artificial neural network-based approach to endoscopic ultrasound elastography in diagnosis of focal pancreatic masses. *Clin Gastroenterol Hepatol* 2012; **10**: 84-90.e1 [PMID: 21963957 DOI: 10.1016/j.cgh.2011.09.014]

67 **Marya NB**, Powers PD, Chari ST, Gleeson FC, Leggett CL, Abu Dayyeh BK, Chandrasekhara V, Iyer PG, Majumder S, Pearson RK, Petersen BT, Rajan E, Sawas T, Storm AC, Vege SS, Chen S, Long Z, Hough DM, Mara K, Levy MJ. Utilisation of artificial intelligence for the development of an EUS-convolutional neural network model trained to enhance the diagnosis of autoimmune pancreatitis. *Gut* 2021; **70**: 1335-1344 [PMID: 33028668 DOI: 10.1136/gutjnl-2020-322821]

68 **Price WN**. Big data and black-box medical algorithms. *Sci Transl Med* 2018; **10** [PMID: 30541791 DOI: 10.1126/scitranslmed.aao5333]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: office@baishideng.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com