World Journal of Gastroenterology

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*World J Gastroenterol* 2025 October 21; 31(39): 110886

DOI: 10.3748/wjg.v31.i39.110886

ISSN 1007-9327 (print) ISSN 2219-2840 (online)

LETTER TO THE EDITOR

# Colonoscopy in the artificial intelligence era: Spotlight on adenoma miss rate

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**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 B, Grade B, Grade C, Grade C, Grade C

**Novelty:** Grade B, Grade B, Grade C, Grade C, Grade C

**Creativity or Innovation:** Grade B, Grade B, Grade C, Grade C, Grade C

**Scientific Significance:** Grade A, Grade B, Grade B, Grade C, Grade C

**P-Reviewer:** Tang YX, MD, China; Toyoshima O, MD, PhD, Japan; Wang XH, MD, PhD, China

**Received:** June 17, 2025

**Revised:** July 23, 2025

**Accepted:** September 18, 2025

**Published online:** October 21, 2025

**Processing time:** 125 Days and 22.7 Hours

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## Abstract

This letter addresses the recent systematic review and meta-analysis by Wang *et al*, which evaluated the role of artificial intelligence-based computer-aided detection (CADe) in reducing adenoma and polyp miss rates during colonoscopy. We commend the authors for highlighting adenoma miss rate (AMR) as a more clinically meaningful endpoint than the traditionally used adenoma detection rate. Their findings demonstrate a significant reduction in AMR and polyp miss rate with CADe-assisted colonoscopy, particularly in small and sessile serrated lesions. However, limitations, including limited study numbers, tandem study design of included studies, and heterogeneity of CADe systems, warrant cautious interpretation. We discuss the broader implications of these findings for real-world practice and future research directions. This letter reinforces the importance of AMR as a performance metric and supports the continued integration and evaluation of artificial intelligence technologies in endoscopic practice to enhance colorectal cancer prevention strategies.

**Key Words:** Artificial intelligence; Colonoscopy; Adenoma miss rate; Adenoma detection rate; Colorectal cancer

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**Core Tip:** Artificial intelligence, particularly computer-aided detection, is increasingly being integrated into colonoscopy to improve neoplasia detection and reduce human error. While most prior meta-analyses have focused on adenoma detection rate, this systematic review and meta-analysis emphasize adenoma miss rate as a more sensitive and clinically relevant outcome. By analyzing five randomized-controlled trials involving 1624 patients, the study demonstrates that computer-aided detection-assisted colonoscopy significantly reduces adenoma miss rate, particularly for small-sized adenomas and sessile serrated lesions. These findings support broader adoption of artificial intelligence in colonoscopy, though real-world validation and long-term outcome studies are still needed to confirm its sustained clinical impact.

**Citation:** Panda K, Pati GK, Dash DP. Colonoscopy in the artificial intelligence era: Spotlight on adenoma miss rate. *World J Gastroenterol* 2025; 31(39): 110886
**URL:** https://www.wjgnet.com/1007-9327/full/v31/i39/110886.htm
**DOI:** https://dx.doi.org/10.3748/wjg.v31.i39.110886

## TO THE EDITOR

Colorectal cancer (CRC) remains one of the leading causes of cancer-related morbidity and mortality worldwide, despite being largely preventable through effective screening and early detection strategies. Colonoscopy, as the gold standard for CRC screening, plays a critical role in identifying and removing precancerous lesions such as adenomas and polyps. However, its diagnostic yield is highly operator-dependent, influenced by factors such as endoscopist experience, fatigue, vigilance, and mucosal visualization[1,2]. These inherent limitations contribute to substantial variability in adenoma detection and can lead to missed lesions, which are a major cause of interval CRCs. In fact, such missed lesions are estimated to account for 50%-60% of interval cancers[3], with an incidence of 3.5 cases of interval cancers from missed lesions per 1000 individuals screened[4].

To address this challenge, artificial intelligence (AI) technologies, particularly computer-aided detection (CADe) systems, have been increasingly integrated into endoscopic practice. These systems leverage deep learning algorithms, often trained on large datasets of annotated colonoscopy images, to assist endoscopists by providing real-time visual alerts for suspected polyps and adenomas. The goal is not to replace the clinician but to augment detection performance, reduce oversight, and standardize quality across operators and institutions[5].

Adenoma detection rate (ADR), defined as the proportion of screening colonoscopies in which at least one adenoma is detected, has long served as the primary quality metric for colonoscopy. Higher ADRs are strongly associated with reduced CRC incidence and mortality[1,2]. International guidelines recommend benchmark thresholds for ADR to assess endoscopist competence[6]. While improvements in overall ADR have been inconsistent across studies, first-pass ADR, reflecting single-procedure performance, has shown more consistent enhancement with CADe use[7,8]. Huang *et al*[9] recently published a meta-analysis of 10 randomized controlled trials (RCTs) including 6629 subjects, where they showed that the AI-assisted colonoscopy group ($n$ = 3300) had significantly higher ADR [risk ratio (RR) = 1.43; $P$ < 0.001] and polyp detection rate (RR = 1.44; $P$ < 0.001) compared to the conventional-colonoscopy group. These benefits were especially pronounced for diminutive (≤ 5 mm) and flat lesions, features often missed during conventional colonoscopy. These findings highlight the potential of CADe systems to mitigate the limitations of human observation and enhance detection consistency.

However, ADR is not without its limitations. It reflects only whether an adenoma was found, not how many were missed. Moreover, ADR can be artificially inflated by the detection of diminutive or non-neoplastic lesions that may not be clinically significant. As CADe systems can increase overall lesion detection, they may inadvertently increase ADR by identifying hyperplastic or redundant findings, which may not reflect true improvements in meaningful detection[10]. Moreover, results from the controlled trials with regard to ADR might not align with broader, everyday clinical environments, as highlighted by Levy *et al*[11] In their real-world cohort, ADR in the post-AI-assisted colonoscopy group was lower compared with the pre-AI group (30.3% *vs* 35.2%, $P$ < 0.001).

In contrast, adenoma miss rate (AMR) has emerged as a reliable metric for evaluating the quality of colonoscopy, particularly in the context of new technologies like CADe. AMR measures the proportion of adenomas missed during the initial examination and found on a subsequent second-pass (tandem) colonoscopy. Several studies have demonstrated that even experienced endoscopists may miss up to 20%-30% of adenomas, especially small, flat, or serrated lesions located in the proximal colon. In a meta-analysis of 43 studies (including 15152 tandem colonoscopies) by Zhao *et al*[12], pooled AMR was 26% [95% confidence interval (CI): 23%-30%], with a higher miss rate for proximal lesions compared to distal ones. Factors significantly associated with higher AMR included older age, female sex, and poor bowel preparation. The study also found that smaller (< 5 mm) and nonpedunculated adenomas had the highest likelihood of being missed.

CADe has shown promising results in mitigating this issue by improving the consistency of mucosal inspection and reducing cognitive burden. As AI-based tools continue to evolve, understanding their true impact requires moving beyond traditional metrics like ADR and embracing more precise indicators of diagnostic accuracy, such as AMR. This paradigm shift has important implications not only for clinical practice but also for training, guideline development, and long-term CRC prevention strategies.

Recent studies have begun to quantify the impact of CADe on AMR and polyp miss rate (PMR), revealing statistically and clinically significant reductions compared to conventional colonoscopy[13]. A recent meta-analysis by Maida *et al*[14],

which included six tandem-design RCTs involving 1718 patients, demonstrated that CADe-assisted colonoscopy significantly decreased AMR by 54% (RR = 0.46, 95%CI: 0.38-0.55; $P < 0.001$) and PMR by 56% (RR = 0.44, 95%CI: 0.33-0.60; $P < 0.001$) compared to conventional colonoscopy. These effects were consistent across screening and surveillance cohorts, and notably, the miss rate for sessile serrated lesions was also significantly reduced (RR = 0.28, 95%CI: 0.11-0.70; $P = 0.007$). However, no significant difference was observed in the detection of advanced adenomas.

We therefore read with great interest the recent publication by Wang *et al*[15] titled "Artificial intelligence for reducing missed detection of adenomas and polyps in colonoscopy: A systematic review and meta-analysis". The authors have commendably addressed a topic of growing relevance: The impact of integrating AI-based CADe into traditional colonoscopic practice on AMR. The work stands out by prioritizing AMR as the primary outcome, a shift from the conventional focus on ADR, offering a more nuanced evaluation of AI's clinical utility. This meta-analysis demonstrates methodological rigor. The authors conducted a comprehensive literature search across major databases and included only RCTs, enhancing the credibility of their findings. The focus on AMR is particularly praiseworthy; AMR, unlike ADR, accounts for lesions missed during the initial colonoscopy and later detected on a second examination, thus serving as a sensitive marker of true diagnostic performance.

Notably, the meta-analysis confirms that CADe-assisted colonoscopy significantly reduces AMR by 66% compared to conventional colonoscopy (RR = 0.34, 95%CI: 0.26-0.45, $P < 0.01$), with moderate heterogeneity ($I^2 = 35\%$). The findings also demonstrate CADe's effectiveness in reducing the PMR by 65% (RR = 0.35, 95%CI: 0.23-0.52; $P < 0.01$) and enhancing first-pass ADR, although no statistically significant advantage was found in detecting advanced adenomas or lesions > 6 mm. Subgroup analyses reveal robust reductions in AMR for sessile serrated lesions and adenomas ≤ 5 mm, areas where conventional detection methods often struggle. The inclusion of sensitivity analyses and funnel plots strengthens confidence in the findings, minimizing concerns about publication bias or study-level heterogeneity. Additionally, the subgroup evaluations by lesion size, location, and histologic type provide practical insights into the potential and limitations of CADe across different clinical scenarios.

### Novel contributions and clinical implications

While valuable, the conventional reliance on ADR may be skewed by CADe's tendency to detect non-neoplastic lesions or duplicate detections, thus inflating performance metrics. AMR, being a direct measure of what is missed, may offer a more clinically relevant endpoint, especially in the context of CRC prevention strategies. Notably, the authors highlight that while ADR during the first-pass examination improved significantly with CADe compared to conventional colonoscopy, overall ADR and adenomas per colonoscopy did not differ between groups in concordance, which is in agreement with previous research[16]. This underscores that CADe's impact may be procedure-specific (*i.e.*, tandem colonoscopy) and might not universally translate to improved long-term outcomes unless integrated into routine clinical workflows. Moreover, the findings suggest that AI can particularly benefit novice endoscopists, reduce operator fatigue, and bring diagnostic performance closer to that of expert endoscopists, an important implication for training programs and settings with limited resources.

### Limitations and areas for future research

Despite its strengths, the study has certain limitations that warrant discussion. Firstly, only five RCTs were included, comprising a modest sample of 1624 patients. While the authors appropriately performed sensitivity analyses, the limited number of studies restricts generalizability, especially across varied geographic and practice settings. Secondly, all included studies employed tandem colonoscopy, a design that, while ideal for capturing AMR, does not mimic real-world clinical practice. Performing two colonoscopies in succession may artificially increase ADR and reduce PMR in both arms due to increased mucosal exposure and observer vigilance. Therefore, the translation of these findings into everyday practice, where only a single-pass colonoscopy is the norm, remains uncertain. Another concern is the heterogeneity in CADe systems used (*e.g.*, EndoScreener, gastrointestinal-genius, computer aided quality-augmented systems), endoscopist expertise levels, and patient populations (screening, symptomatic, surveillance). One study even used dual AI systems, potentially introducing a confounding effect. These variations could influence diagnostic performance and limit cross-comparability.

Additionally, the study acknowledges that AI performance may be influenced by bowel preparation quality, a variable that was not standardized across included trials. Poor bowel prep can obscure lesions and limit AI efficacy, making this an important confounder that should be adjusted for in future studies. While AMR is a more objective and clinically meaningful metric than ADR, it too has limitations. It does not account for false positives, operator bias during the second pass, or overdiagnosis of clinically insignificant lesions. Consequently, AMR should be interpreted in conjunction with complementary measures such as histopathological relevance and patient-centered outcomes, including CRC incidence and mortality, to provide a more holistic assessment of diagnostic effectiveness. Furthermore, its routine application in real-world practice remains restricted due to the logistical constraints of tandem colonoscopy and associated patient risks. The adoption of AI-assisted colonoscopy may require substantial investments in infrastructure, training, and system maintenance, posing challenges for resource-limited healthcare settings. Moreover, patient perceptions of AI involvement in clinical decision-making could influence acceptance, satisfaction, and trust in the procedure.

### Future directions

Recognizing these limitations highlights the need for further research to strengthen the clinical applicability of CADe systems. Large-scale, multicenter RCTs conducted across diverse healthcare settings are essential to validate the generalizability of current findings. Such studies should incorporate longer follow-up periods to evaluate whether improved detection rates translate into reduced interval cancers and better long-term outcomes. Cost-effectiveness analyses would

also be valuable, as the deployment of AI systems may incur upfront costs but could result in downstream savings through better prevention and reduced cancer treatment expenditures. Furthermore, there is a need to assess the psychological impact of AI use on endoscopists. Does AI enhance or hinder clinical judgment? Can over-reliance on AI reduce skill acquisition among trainees? These are important questions that future qualitative research must explore.

Lastly, the integration of real-time assistive systems and hybrid approaches, such as combining CADe with mechanical enhancements like Endocuff, could be the next frontier in colonoscopic innovation. Future research should also include head-to-head comparisons of various AI platforms to identify the most effective systems across different practice settings. Moreover, studies evaluating the impact of CADe on endoscopist learning curves, cognitive load, and decision-making processes at varying levels of experience are needed to understand its influence on clinical performance and training. Addressing these research gaps will be vital to form evidence-based guidelines and optimize the real-world deployment of AI-assisted colonoscopy.

### *Conclusion*

In sum, this work provides timely and clinically relevant insights by rigorously evaluating the role of AI in reducing adenoma and PMRs during colonoscopy. The study highlights AMR as a marker that might be more reliable than the traditionally emphasized ADR in assessing diagnostic performance. While limitations remain in terms of generalizability and real-world applicability, the evidence presented is compelling and opens new avenues for the application of AI in endoscopic practice.

## FOOTNOTES

**Author contributions:** Panda K and Pati GK designed the overall concept and outline of the manuscript; Panda K performed the literature search and wrote the initial draft; Pati GK and Dash DP provided the necessary intellectual inputs, reviewed, and edited the manuscript. All the authors have read and approved the final version of the manuscript.

**Conflict-of-interest statement:** All the authors report no relevant conflicts of interest for this article.

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**S-Editor:** Wu S
**L-Editor:** A
**P-Editor:** Lei YY

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