EDITORIAL

Artificial intelligence (computer-assisted detection) is the most recent novel approach to increase adenoma detection

Quality improvement in colorectal cancer screening and surveillance by colonoscopy is based on the assumption that an increase in adenoma detection rate (ADR) has the potential to decrease the risk of colorectal cancer. Techniques and technologies to improve ADR evaluated in a recent network meta-analysis[1] included add-on devices (cap, endocuff, endoring, G-EYE), enhanced imaging techniques (chromoendoscopy, narrow-band imaging, flexible spectral imaging color enhancement, blue laser imaging), new endoscopes (full-spectrum endoscopy, extra-wide-angle-view colonoscopy, dual focus), and low-cost optimizing of existing resources (water-aided colonoscopy, second observer, dynamic position change), alone or in combination with high-definition colonoscopy or each other. The network meta-analysis showed that in comparison with high-definition colonoscopy, a moderate increase in ADR was associated with low-cost optimizing of existing resources, enhanced imaging techniques, and add-on devices. There was low to moderate confidence in estimates. Compared with high-definition colonoscopy, the use of newer endoscopes was not associated with significant increases in ADR. No specific technology for increasing ADR was superior to others in a comparative efficacy analysis. There were no significant differences among technologies in advanced ADR, polyp detection rate, or mean number of adenomas per patient (APC).

In the current issue of *Gastrointestinal Endoscopy*, a meta-analysis has added artificial intelligence as another novel technique that significantly increases ADR.[2] Five randomized controlled trials (4354 patients) using computer-aided detection (CADe) compared with standard control colonoscopy were analyzed.[3-7] The pooled ADR was significantly higher in the CADe group than that in the control group. APC was higher in the CADe group than in the control group. The CADe group also had higher APC according to subgroup analyses for size (<5 mm, 6 to 9 mm, and ≥10 mm), location (proximal and distal), and morphology (flat and polypoid). CADe revealed more sessile serrated lesions, whereas a nonsignificant trend for increase in advanced adenomas was found. Thus, the use of CADe resulted in a significant improvement in colonoscopy quality indicators. The effect was independent of main adenoma characteristics. Advanced adenoma is a more important surrogate marker of colorectal cancer. As analyzed by the original authors, the enrolled studies showed that CADe did not increase advanced ADR. Analyzed together in the current meta-analysis, CADe significantly increased the detection rate of large (≥10 mm) adenomas (a type of advanced adenoma). In the absence of results from pathologic examination, an increase in advanced ADR (with features of villous or dysplastic changes) by CADe could not be addressed. The ADRs of the CADe group (34.0%) and the control group (23.3%) were lower than those in other reports in the literature. The lower-than-usual ADR casts doubt on whether enhancement of ADR by CADe could be generalized to settings with higher baseline ADRs. The Italian study[5] seems to confirm that a similar beneficial effect on ADR by CADe occurs with experienced colonoscopists with higher baseline ADRs. However, the increase by the CADe arm as a percentage of the control arm appears to be less for colonoscopists with higher ADRs than for colonoscopists with lower ADRs (Table 1). The phenomenon was also well illustrated by the 2 studies conducted by the same group. Although the same CADe system was used, the percentage increase in ADR decreased from 43.3% to 21.3% (Table 1) when experienced colonoscopists performed the examinations.[3,4]

> Drawbacks aside, a well-trained CADe system can overcome the limitations of the human eye and uniformly increase the ADR regardless of the characteristics of the polyps. The inference is that CADe can be combined with any of the techniques and technologies described in the meta-analysis mentioned above to yield even higher detection rates.

The main goal of the meta-analysis by Hassan et al[2] was to assess the impact of CADe. The increase in ADR by CADe is unquestionably a major achievement of advocates of artificial intelligence in colorectal cancer

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TABLE 1. Adenoma detection rate and increase as percentage of control

Reference	ADR (CADe vs control)	Increase (% control)
3	29.1% vs 20.3%, $P < .001$	43.3%
4	34% vs 28%, $P = .03$	21.3%
5	54.8% vs 40.4%, $P < .001$	35.6%
6	39.1 % vs 23.9%, $P < .001$	63.5%
7	28.9% vs 16.5%, $P < .001$	75.1%

ADR, Adenoma detection rate; *CADe,* computer-aided detection.

TABLE 2. Limitations of artificial intelligence (computer-aided detection)

Reference	Significantly more detection of non-neoplastic polyps in reference 3, 4, and 6 suggested potentially unnecessary polypectomies in the CADe group (control vs CADe, n [%])	False alarms
3	Hyperplastic and inflammation polyps, 94 (34.9) vs 217 (43.6), $P < .001$.	39 false alarms; an average of 0.075 false alarms per colonoscopy
4	Hyperplastic and inflammation polyps, 113 (37) vs 200 (40), $P < .0001$.	48 false detections in the CADe group; an average of 0.1 per colonoscopy
5	No increase in non-neoplastic (hyperplastic, inflammatory) lesions, 57 (16.6) vs 68 (19.9), $P = .254$.	Not assessed in the trial but was 0.9% when the model was evaluated before the trial
6	Proliferative and inflammatory polyps, 92 (37.1) vs 203 (41.9), $P < .001$.	36 false positive results; an average of 0.071 false alarms per colonoscopy
7	Not reported.	62 false prompts (false positive results) in the AQCS group; an average of 0.201 false prompts per colonoscopy

AQCS, Automatic quality control system; *CADe,* computer-aided detection.

screening and surveillance. When we reviewed the 5 articles included in the meta-analysis, there was an increase in the detection of nonneoplastic polyps in 3[3,4,6] of the 5 reports (no increase in one[5] and not reported in another[7]) (Table 2). The histologic diagnosis necessitated removal of these polyps during colonoscopy. Except for the report by Repici et al[5] showing that resection of non-neoplastic polyps was similar between CADe and standard colonoscopy, the 3 studies[3,4,6] with significantly higher detection rates of non-neoplastic polyps (Table 2) suggested that CADe was associated with polypectomies, which might not have been necessary. Nonetheless, the removal of proximal hyperplastic polyps is justified because of the possible development of colon cancer through the serrated pathway.

False alarms are detected lesions continuously traced by the CADe system but deemed not to be polyps by the endoscopist. False positive results are activation of the system, irrespective of the number of frames or duration of time not due to any polypoid or nonpolypoid lesions. These entities can conceivably distract the colonoscopist from focusing on identifying a real polyp and plausibly reduce the efficiency of the withdrawal inspection. The clinical relevance of false positive results was evaluated in an in-press article.[8] Of the 27.3 mean false positive results per colonoscopy, 1.6 (5.7%) required an additional exploration time of 4.8 seconds per false positive result, taking up only 0.7% of the mean withdrawal time. The amount of extra time spent on false positive results is only about 5 seconds per flagged lesion and accounts for about 1% of total withdrawal time. Thus, timewise, false positive distractions are negligible.[8] It is not known, however, whether the duration taken up by these evaluations, or the mere fact that they cause even transient distractions, could bring about a negative impact on the primary task of inspection for real polyps. The 5 reviewed trials in the current meta-analysis were unblinded. The authors did not provide their baseline ADRs before the start of the trials to reflect the absence of inadvertent or deliberate poor performance in the control group.

Drawbacks aside, a well-trained CADe system can overcome the limitations of the human eye and uniformly increase the ADR regardless of the characteristics of the polyps. The inference is that CADe can be combined with any of the techniques and technologies described in the meta-analysis[1] mentioned above to yield even higher detection rates. This brings us to the interesting question, "Which technique or technology is likely to complement the performance of artificial intelligence in further increasing ADR?"

In an invited review,[9] we addressed the potential of combining artificial intelligence and water exchange to increase ADR. In this editorial, we discuss the

possibility that the strengths of artificial intelligence and water exchange could complement each other's limitations to optimize the outcomes. Artificial intelligence has the potential to increase ADR and polyp detection rate with any of the new methods,[1] which can be negatively affected by the colonoscopist's inattention or inadequate inspection techniques. On the other hand, artificial intelligence entails false alarms and false positive results.

The studies that demonstrated the positive impact of water exchange on enhancing ADR were referred to in our invited review.[9] Additionally, in a pooled data analysis of 6 randomized controlled trials, water exchange was shown to significantly enhance overall and advanced ADR and to improve bowel cleanliness.[10] Placed along the broader context of options to increase ADR, water exchange could provide a more attractive platform for CADe by improving bowel cleanliness and reducing false alarms.

Thus, artificial intelligence could complement water exchange by detecting polyps overlooked by the colonoscopist as a result of either inexperience or inattention. Water exchange could complement artificial intelligence by salvage cleaning during insertion to enhance polyp exposure and reduce false alarms, which also can be a source of distraction during withdrawal inspection. Combining water exchange and artificial intelligence would hold the promise of begetting breakthroughs in the approach to optimally improve polyp and adenoma detection.

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Abbreviations: ADR, adenoma detection rate; APC, adenomas per patient; CADe, computer-aided detection.

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