Artificial intelligence in colonoscopy: where have we been and where should we go?

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The use of artificial intelligence (AI) in colonoscopy has gathered significant attention in recent years. Successful execution and publication of randomized trials have paved the way to Food and Drug Administration (FDA) approval of a handful of computer-vision based AI assistant tools in colonoscopy (1). However, it is yet to take a lead role as a helpful aid to the endoscopist on a day-to-day basis. Especially so in the private gastroenterology [gastrointestinal (GI)] practice setting where the majority of the population-based screening colonoscopies are performed (2). Although a good number of private practice settings in the US have tried some of the commercially available AI assistants in colonoscopy, most of them (to the best of our knowledge) have abandoned its ongoing use due to prolonged overall procedure time. A very important limitation in private GI practice. In fact, in a meta-analysis of six randomized controlled trials (RCTs) evaluating the use of real-time computer aided tools in colonoscopy, the withdrawal time was significantly greater in comparison to standard colonoscopy when AI was utilized (1).

We should ensure that we all talk the same language when it comes to AI. AI encompasses every aspect of machine learning, where computer-based algorithms and softwares make tasks easier. A set of learning inputs are used to pre-train the system, and the system then generates outcome predictions on an unknown new data input. Computer vision is a branch of machine learning that is specific for identifying objects from an image or a video. Computer vision is the backbone of all 'face-recognition' technology, self-driving cars, and is also the concept that goes behind identifying polyps or pretty much anything of interest (like bleeding, or ulcers) in an image (whether it comes from a video capsule image, a colonoscopy image, or any endoscopy image).

Convolutional neural networks (CNN) belong to deep-learning (a subset of machine learning) methods where the algorithms are connected by multiple arrays of 'logistic-regression' connections or 'nodes'. Only certain data detail at a specific numerical (to the decimal point in almost all cases) cut-off would get transmitted to the next level, so on and so forth to generate a final outcome, when all analyzed features of input data is broken up and evaluated through the CNN framework. With regards to colonoscopy and polyp detection, various terms have been used to describe the role of computer-aided systems, such as computer aided detection (CADe) and computer aided diagnosis (CADx). The difference in these terms is just the output parameter. Detection detects a polyp, whereas diagnosis characterizes the polyp (3). The machine learning algorithm is however agnostic to these terms.

Randomized trials have, indeed, demonstrated better adenoma detection rates (ADRs) with the use of AI-tools in colonoscopy as compared to endoscopists alone. It is important to note that both cohorts met appropriate ADR benchmarks. However, the withdrawal time was significantly greater in the AI arm based on pooled data as mentioned above and it is an established fact that prolonged withdrawal times directly correlate with increased ADRs (1). Therefore, does AI really add any additional advantage by improving the ADR? Common sense would indicate that it should, as

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improvements in ADR have been directly linked to reduced rates of interval colorectal cancers (CRC). Nevertheless, endoscopists have started questioning the utility of adding a box around a polyp that they can already see!

Having said that, could a CADx based system one day help replace the need for pathologic analysis of diminutive polyps? Can endoscopists just 'resect and discard' small polyps or maybe just 'diagnose and leave' them? In a direct head-to-head comparison study of two commercially available CADx systems, there was good concordance with 'resect and discard' strategy *in vivo* between the two different systems (4). However, the results were robust among rectosigmoid polyps, which might not be of much interest among experienced endoscopists who are already comfortable with 'diagnose and leave' strategy for hyperplastic polyps in the rectosigmoid. Nevertheless, the current limitation of CADx that only characterizes a polyp into neoplastic vs non-neoplastic might be overcome in near future. It would be interesting to see how real-life results would manifest once CADx systems are trained to report granular polyp characterizations such as tubular adenoma, tubulo-villous adenoma or sessile serrated lesions (SSL).

An interesting area of investigation would be to see if AI-tools improve detection of sessile serrated polyps/SSL. Clearly, deep-learning CNN algorithms are needed that specifically train on SSL images. Although a 'training-testing' strategy would invariably demonstrate high diagnostic accuracy, real-life randomized data would be needed to establish the role of CADx in characterizing SSLs. Therefore, at the current time, the use of AI in the detection of sessile serrated polyps is not established.

Another interesting avenue of exploring the use of AI in colonoscopy is to study the completeness of luminal examination of the colon. Missed examination of mucosal surface around turns, behind folds and secondary to looped scope are difficult to ascertain during regular colonoscopy. Techniques such as a second cecal intubation, retroflexion in cecum and controlled withdrawal around corners have been recommended, however, there is no objective measure of missed area of mucosal examination. Data scientists have come up with preliminary methods of quantifying the luminal surface area of the colon, followed by training deep learning algorithms that can potentially assess areas visualized, areas examined and areas that were potentially not visualized. Using CNN and employing the basics of computer vision (namely feature extraction and classification) the system can be trained to identify blurred images, inadequate bowel cleansing, and instances of inadequate bowel insufflation (5). Randomized data has been published demonstrating real-time automated monitoring of withdrawal time, speed and adequacy of mucosal exposure (6). Furthermore, data is already published regarding validation of deep learning models for the quantification of the quality of bowel preparation (7). This would be an exciting area to watch out for in the future.

Deep learning models to automatically assess colon polyp size are being explored (8). AI systems have been trained to assess disease severity in inflammatory bowel disease (IBD) (9). Research on the use of computer assistance in colon capsule endoscopy are currently in its preliminary stage of evaluation (10).

In summary, immediate research on the use of AI-tools in colonoscopy must focus on key areas of interest including identifying SSLs, automated measurement of polyp size and identifying unexamined parts of the colon. In future, AI-assistance in the training of GI fellows, and AI-guided ergonomics would enrich and help objectively standardize the training of future endoscopists. It appears we are only in the early phases of AI development and adoption at this time.

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Footnote

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