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MINIREVIEWS

Role of endoscopic ultrasound in non-variceal upper gastrointestinal bleeding management

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Abstract

Non-variceal upper gastrointestinal bleeding (NVUGIB) is one of the challenging situations in clinical practice. Despite that gastric ulcer and duodenal ulcer are still the main causes of acute NVUGIB, there are other causes of bleeding which might not always be detected through the standard endoscopic evaluation. Standard endoscopic management of UGIB consists of injection, thermal coagulation, hemoclips, and combination therapy. However, these methods are not always successful for rebleeding prevention. Endoscopic ultrasound (EUS) has been used recently for portal hypertension management, especially in managing acute variceal bleeding. EUS has been considered a better tool to visualize the bleeding vessel in gastroesophageal variceal bleeding. There have been studies looking at the role of EUS for managing NVUGIB; however, most of them are case reports. Therefore, it is important to review back to see the evolution and innovation of endoscopic treatment for NVUGIB and the role of EUS for possibility to replace the standard endoscopic haemostasis management in daily practice.

Key Words: Non-variceal upper gastrointestinal bleeding; Endoscopic haemostasis; Endoscopic ultrasound; Bleeding vessel; Doppler image

Core Tip: Non-variceal upper gastrointestinal bleeding is still one of the challenging situations in clinical practice. Standard endoscopic hemostasis has shown to have a high successful bleeding control rate; however, in some types of bleeding, there is still a possibility for endoscopic treatment failure. Endoscopic ultrasound can give a better bleeding vessel visualization, and it has shown to be a promising tool for non-variceal upper gastrointestinal bleeding management.

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INTRODUCTION

Upper gastrointestinal bleeding (UGIB) is one of the challenging situations in clinical practice due to its etiology, location, types of bleeding, and severity. It comprises of non-variceal and variceal bleeding[1,2]. In the past, there has been no significant change from time to time regarding the etiology of non-variceal upper gastrointestinal bleeding (NVUGIB). Gastric ulcer (GU) and duodenal ulcer (DU) are still the main causes of acute NVUGIB, where hemorrhage and perforation are the major causes for mortality[3,4]. A recent large multicenter study showed that the bleeding etiology for NVUGIB was dominated by DU, followed by GU, whereas neoplasia was ranked as the fourth common cause of NVUGIB when compared to other non-malignant causes, such as Mallory-Weiss, esophagitis, and Dieulafoy's lesion. Recurrent bleeding was found in 3.2% of patients, with a 4.5% mortality rate in 30 d. Standard endoscopic treatment, which consists of injection, thermal coagulation, hemoclips, and combination therapy, has shown a good bleeding control rate. However, endoscopic treatment failure was still found to be higher in patients with several predictors, such as in-hospital bleeding, hematemesis, renal failure, neoplasia, and liver cirrhosis[5]. Recently, there has been innovation management using endoscopic ultrasound (EUS) for managing variceal bleeding as it can target the bleeding vessel much better than conventional endoscopic management[6]. Therefore, in this review, the role of EUS will be discussed further.

METHODS

We collected all articles which have been published on standard endoscopic management as well as endoscopic ultrasound guided management in UGIB through the Medline/PubMed databases. The keywords used were EUS-guided vascular therapy, upper gastrointestinal bleeding, and non-variceal upper gastrointestinal bleeding. The purpose of this review was to elaborate the standard endoscopic management, limitations, new development or technique innovation, bleeding causes, and patient's outcome.

ENDOSCOPIC MANAGEMENT FOR NON-VARICEAL UPPER GASTROINTESTINAL BLEEDING

Standard endoscopic hemostasis treatment for NVUGIB consists of drug injection (epinephrine, cyanoacrylate, and other sclerosing agents), thermal coagulation, mechanical method, as well as topical treatment[7]. Endoscopic findings and bleeding ulcer stratification based on Forrest class have been routinely used as a standard parameter for the decision of endoscopic treatment options. Based on the Forrest classification, active bleeding (classes IA and B) has a 55% rebleeding rate with a 11% mortality rate, followed by visible vessel (class IIA) with a 43% rebleeding rate and 11% mortality rate, adherent clot (class IIB) with a 22% rebleeding rate and 7% mortality rate, flat spot (class IIC) with a 10% rebleeding rate and 3% mortality rate, and clean base ulcer (class III) with a 5% rebleeding rate and 2% mortality rate[8]. A randomized controlled trial by Chau *et al*[9] looking at the role of epinephrine injection combined with heat probe coagulation therapy *vs* epinephrine injection combined with argon plasma coagulation treatment in patients with bleeding peptic ulcers showed no significant difference between the two combined methods in achieving successful hemostasis (95.9% *vs* 97.7%). This study mostly included patients with Forrest classes IB and IIA. However, the rebleeding rate from both of groups was still high (21.6% and 17.0%), and the hospital mortality was 6.2% and 5.7%, respectively. Another randomized controlled trial by Lo *et al*[10] showed that combined therapy using epinephrine injection with hemoclip therapy *vs* epinephrine injection alone was more effective in reducing the rebleeding rate (100% *vs* 33%, P = 0.02). In fact, no surgery was even required in the combination treatment group when compared to the single treatment group (P = 0.023). The use of clips in NVUGIB might be associated with less mucosal injury when compared to thermal therapy[11]. In 2010, a novel endoscopic method using electrocautery forceps alone or with combined method based on retrospective multicenter data from patients with nonmalignant gastroduodenal ulcer bleeding in Japan showed that the rate of successful bleeding control was achieved in 96.8% of peptic ulcer patients, and 100% of artificial ulcer patients. However, there were 12 patients with rebleeding, which consisted of seven (11.5%) peptic ulcer patients and five (7.6%) artificial ulcer patients. In the rebleeding management, only one patient needed repeat endoscopic hemostasis treatment, and one patient required surgery after undergoing combination treatment. However, this study has been limited by the patient's selection bias as well as the endoscopist's procedure skill[12]. Another innovation on endoscopic management on UGIB using a novel hemostatic powder (the "GRAPHE" registry), TC-325, showed that the immediate bleeding control effect was achieved by 96.5% of the patients; however, recurrent bleeding was found in 26.7% of patients at day 8 and 33.5% at day 30. Melena and pulsatile bleeding were the two most important factors for recurrent bleeding[13]. A large multicenter prospective study by Kawaguchi *et al*[14] showed that the most frequent cause of NVUGIB was gastric ulcer (GU; 69%), followed by DU (27%) and gastroduodenal ulcer (4%). The in-hospital 4-wk mortality rate was 5%, where two patients who died were associated with the bleeding itself. Patients with DU had a significantly higher mortality rate when compared to patients with GU (16% *vs* 4%, P = 0.014). In this study, 20 patients (8%) had unsuccessful endoscopic treatment. Other factors were comorbidities, the use of antithrombotic agent, and in-hospital onset. Based on the guideline recommendations from the international consensus group for NVUGIB management, it has been suggested that TC-325 can become a temporary treatment option with low evidence. This is due to its high rebleeding rates after 72 h and 1 wk. Endoscopic treatment, such as epinephrine injection, thermal coagulation, and clipping, is still considered as the main treatment. However, there was no significant difference in term of mortality rate even with combination therapy [15].

ENDOSCOPIC ULTRASOUND EVOLUTION AND INNOVATION IN MANAGING NON-VARICEAL UPPER GASTROINTESTINAL BLEEDING

In the evolution of therapeutic EUS development, a pioneer study by Boustière *et al*[16] performed EUS in liver cirrhotic patients, where gastric varices could be identified and stratified much better than esophageal varices. All cases suspected with the presence of GV was confirmed by EUS examination. In 2000, Lee *et al*[17] published a study on EUS-guided cyanoacrylate injection for bleeding GV showed that repeated injection under EUS guidance might improve patient survival as the recurrent bleeding incidence was decreased significantly when compared to on-demand treatment. Another small case series study by Romero-Castro *et al*[18] showed successful EUS-guided cyanoacrylate injection for the perforating veins related to GV. These innovation studies also have been supported by a recent acute variceal bleeding case series study[19], which concluded that EUS can give accurate approach in varices treatment (Figure 1). In 2011, a study by Binmoeller *et al*[20] showed that EUS-guided transesophageal combined treatment using coil and cyanoacrylate for GV management achieved a success in all cases. The rebleeding was noted to be not associated with the variceal bleeding. This was followed and supported by a recent study published by Bick *et al*[21], where they showed that by using EUS, the GV can be covered in a larger number when compared to the standard endoscopic injection. In fact, the use of EUS for NVUGIB management also has been studied in the past; however, most of them were only case report studies[22]. The first well-known case series study was published in 1996, which described the use of EUS examination for Dieulafoy's lesion evaluation and management. Three patients underwent sclerotherapy injection using 1% polidocanol under EUS guidance successfully without any adverse events[23]. This study was supported by other two case reports in patients who experienced bleeding due to Dieulafoy's lesion. One case report described the treatment using thermal contact with 7F Bicap probe (Boston Scientific). This probe was passed through the EUS channel combined with 2.5 mL absolute alcohol, which resulted in deep mucosal thermal burn, thus reducing the amplitude of arterial wave form. Another case underwent endoscopic band ligation after EUS evaluation. There was no rebleeding after the first procedure in both cases[24,25]. In 2008, Levy *et al*[26] published a study on EUS-guided angiotherapy for refractory NVUGIB, which consisted of bleeding due to hemosuccus pancreaticus, Dieulafoy's lesion, DU, and gastrointestinal stromal tumor (GIST), and occult GI bleeding. In this case series study, absolute alcohol injection was performed for hemosuccus pancreaticus bleeding and Dieulafoy's lesion, and cyanoacrylate injection for DU and GIST patients. All patients in this study did not have any rebleeding episodes, even after more than 12 mo. A larger case series study by Law *et al*[27] on the use of EUS-guided hemostasis treatment in patients with resistant non-variceal bleeding (GIST, colorectal vascular malformations, duodenal masses or polyps, Dieulafoy's lesions, DUs, and rectally invasive prostate cancer), showed that the complete vascular cessation was achieved in 63% of patients and the flow decrease in 37% of patients. There were no adverse events observed after the procedure. No patients had rebleeding within 12 mo follow-up after the procedure. Two studies reported only bleeding due to pancreatic pseudoaneurysm. One study reported a patient with chronic pancreatitis and splenic vein thrombosis with portal hypertension, who underwent EUS-guided pancreatic pseudocyst drainage and endoscopic retrograde cholangiopancreatography, followed by laparoscopic cholecystectomy for biliary tract stones. The late bleeding was due to the presence of pseudoaneurysm close to the pancreatic pseudocyst drainage area. The bleeding was controlled with *n*-butyl cyanoacrylate injection under EUS guidance. No recurrent bleeding was observed after the hemostatic procedure. The other case was a patient experiencing pseudoaneurysm induced by hemosuccus pancreaticus which has been confirmed by computed tomography angiography. This patient underwent EUS-guided coil embolization. No bleeding was recorded after more than a year[28,29]. The role of EUS-guided vascular therapy also has been reported in visceral pseudoaneurysm. The first case was reported by Lameris *et al* [30], where a thrombin-collagen compound was injected into pseudoaneurysm and the Doppler study revealed complete obliteration. No rebleeding occurred during 10 mo follow-up. Sharma *et al*[31] reported bleeding from visceral pseudoaneurysm due to acute pancreatitis, and it was successfully controlled by human thrombin injection. A recent single-blind study by Jensen *et al*[32] in 148 patients with severe NVUGIB who underwent endoscopic hemostasis under Doppler guidance showed that the rebleeding rate was significantly lower when compared to the control group (11.1% *vs* 26.3%, P = 0.0214). However, the use of EUS with Doppler guidance would give more accuracy and advantage to detect the bleeding source and manage severe NVUGIB due to possible poor visualization during standard endoscopic hemostasis procedure (Figure 2).

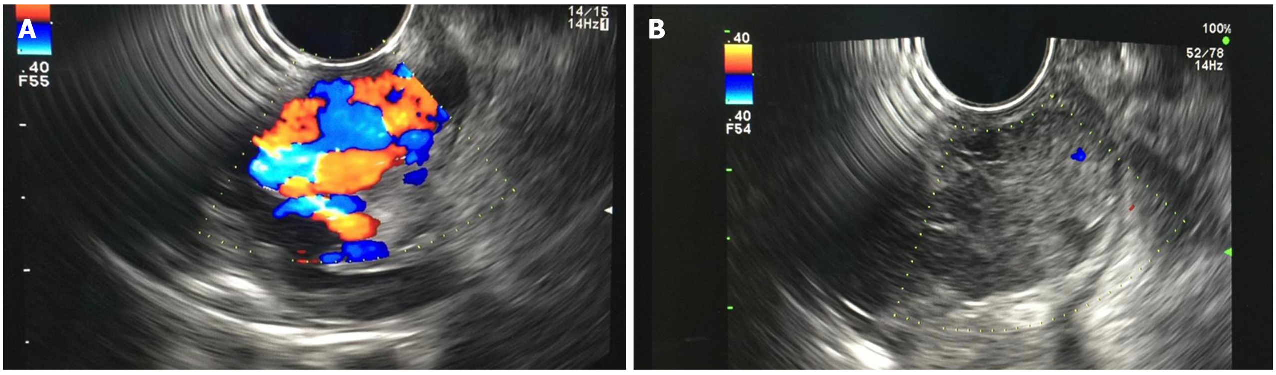

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Figure 1 Gastric varices images before and after endoscopic ultrasound guided cyanoacrylate injection. A: Endoscopic ultrasound (EUS) image of large gastric varices; B: EUS image of gastric varices post cyanoacrylate injection. Endoscopy database Medistra Hospital, Jakarta.

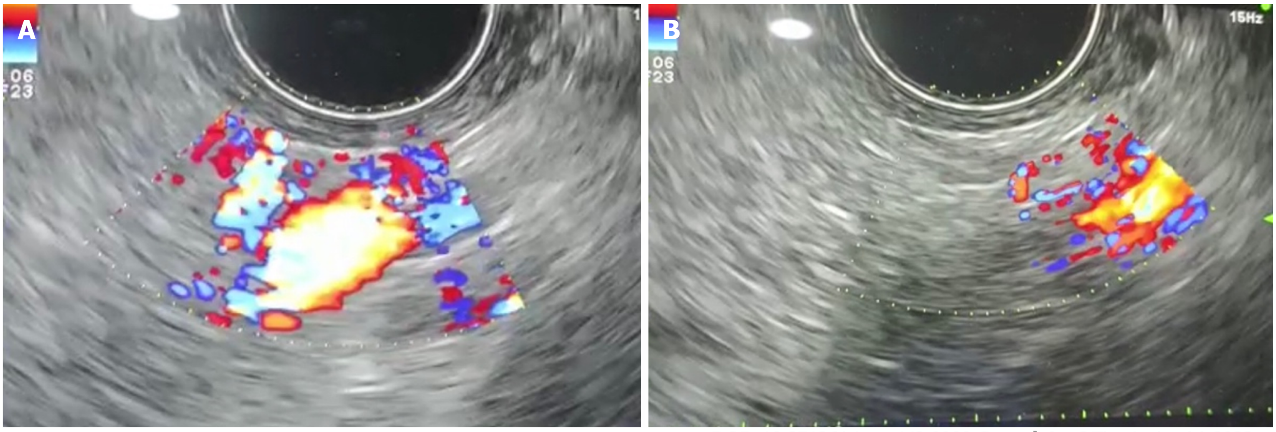

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Figure 2 Deep vascular bleeding source detection through endoscopic ultrasound (EUS) and after EUS-guided cyanoacrylate injection. A: Deep vascular bleeding source detection based on endoscopic ultrasound (EUS); B: EUS image after cyanoacrylate injection to control the bleeding source. Endoscopy database Medistra Hospital, Jakarta.

CONCLUSION

NVUGIB is still a challenging situation where there are a variety of causes which sometimes cannot be detected through standard endoscopic examination. EUS has shown that it has an important role in managing UGIB, especially in NVUGIB. However, it still needs larger study before it can be recommended as the first-line approach in managing NVUGIB.

FOOTNOTES

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ORIGINAL ARTICLE

Retrospective Cohort Study

Artificial intelligence fails to improve colonoscopy quality: A single centre retrospective cohort study

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Abstract

BACKGROUND

Limited data currently exists on the clinical utility of Artificial Intelligence Assisted Colonoscopy (AIAC) outside of clinical trials.

AIM

To evaluate the impact of AIAC on key markers of colonoscopy quality compared to conventional colonoscopy (CC).

METHODS

This single-centre retrospective observational cohort study included all patients undergoing colonoscopy at a secondary centre in Brisbane, Australia. CC outcomes between October 2021 and October 2022 were compared with AIAC outcomes after the introduction of the Olympus Endo-AID module from October 2022 to January 2023. Endoscopists who conducted over 50 procedures before and after AIAC introduction were included. Procedures for surveillance of inflammatory bowel disease were excluded. Patient demographics, proceduralist specialisation, indication for colonoscopy, and colonoscopy quality metrics were collected. Adenoma detection rate (ADR) and sessile serrated lesion detection rate (SSLDR) were calculated for both AIAC and CC.

RESULTS

The study included 746 AIAC procedures and 2162 CC procedures performed by seven endoscopists. Baseline patient demographics were similar, with median age of 60 years with a slight female predominance (52.1%). Procedure indications, bowel preparation quality, and caecal intubation rates were comparable between groups. AIAC had a slightly longer withdrawal time compared to CC, but the difference was not statistically significant. The introduction of AIAC did not significantly change ADR (52.1% for AIAC *vs* 52.6% for CC, $P = 0.91$) or SSLDR (17.4% for AIAC *vs* 18.1% for CC, $P = 0.44$).

CONCLUSION

The implementation of AIAC failed to improve key markers of colonoscopy quality, including ADR, SSLDR and withdrawal time. Further research is required to assess the utility and cost-efficiency of AIAC for high performing endoscopists.

Key Words: Artificial intelligence; Colonoscopy quality; Adenoma detection rate; Sessile serrated lesion detection rate; Withdrawal time

Core Tip: This paper investigates the utility of Artificial Intelligence Assisted Colonoscopy (AIAC) in enhancing colonoscopy quality, particularly adenoma detection rate. Using a retrospective design, we compare AIAC with conventional colonoscopy in a real-world setting, finding no significant improvement in surrogate markers of colonoscopy quality. We explore challenges in artificial intelligence-human interaction and emphasise the need for further validation.

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INTRODUCTION

Screening colonoscopy has been instrumental in reducing the incidence and mortality from colorectal cancer (CRC). However, up to 9% of CRCs develop in patients up-to-date on surveillance colonoscopies, termed interval cancers, thought to overwhelmingly result from suboptimal examination[1]. In defining colonoscopy quality, the most widely used quality metric is adenoma detection rate (ADR), which is the proportion of screening colonoscopies where at least one adenoma is found[2]. As ADR is inversely correlated to the interval cancer rate[3], technology that can aid adenoma detection has been the focus of intense research.

Artificial Intelligence Assisted Colonoscopy (AIAC) has emerged as a potential tool for improving colonoscopy quality and mitigating factors such as proceduralist fatigue or inattention in a procedure that is substantially operator dependent. Early robust randomised controlled trial (RCT) data on computer-aided polyp detection (CADe), which involves neural networks processing colonoscopy images in real time and superimposing a visual alert over suspected polyps on the endoscopy display, has garnered strong enthusiasm for this field[4]. Indeed, meta-analysis of published RCTs suggest that CADe can improve ADR by as much as 10%[5,6]. However, the majority of included trials were single-center studies conducted largely in Chinese institutions with relatively low baseline ADRs and using proprietary technology not available commercially[7]. As such, published data on the utility and cost-effectiveness in real-world clinical settings is limited. The objective of our study was to assess the effect of AIAC on key benchmarks of colonoscopy quality including ADR, sessile serrated lesion detection rate (SSLDR), and withdrawal time in comparison to conventional colonoscopy (CC).

MATERIALS AND METHODS

This was a single-centre retrospective observational cohort study conducted at Redcliffe Hospital, a public secondary hospital in Brisbane, Australia, which provides an open-access endoscopy service. All consecutive colonoscopies from October 2021 until January 2023 were included in the study. Patients were identified through a prospectively maintained departmental database of all patients undergoing colonoscopy. The introduction of the Olympus End-AID module in October 2022 allowed us to compare outcomes for CC in the preceding year with those of AIAC in the subsequent three months. For inclusion, proceduralists must have performed at least 50 colonoscopies both before and after the introduction of the Endo-AID module. We also only included patients with an intact colon. Colonoscopies performed for the surveillance of inflammatory bowel disease were excluded. All endoscopists included in the study had at least five years of independent endoscopy experience.

The primary endpoint for the study was change in three surrogate markers of colonoscopy quality with artificial intelligence (AI): ADR, SSLDR and withdrawal time. Additional variables collected included patient demographics, proceduralists specialisation, indication for colonoscopy, polyp size and colonoscopy quality metrics including bowel preparation and caecal intubation rate.

Proceduralists were able to switch the AI assistance mode on and off and use adjunctive techniques to enhance polyp detection, such as distal cap, narrow band imaging or chemical chromoendoscopy at their discretion. All patients underwent split bowel preparation, and the quality of preparation was evaluated and graded using the Boston Bowel

Preparation Scale by the performing proceduralist. All procedures were performed under conscious sedation using a combination of fentanyl and midazolam. The final decision regarding polyp resection was at the discretion of the proceduralist. Procedures were conducted in one of two dedicated endoscopy rooms equipped with identical high-definition colonoscopes (Olympus EVIS EXTRA) and histopathology was performed at a single laboratory, Queensland Pathology.

Statistical analysis

Statistical analysis was performed using Stata Corp STATA software (Boston, United States). Using ADR as the primary outcome and anticipating an effect size of 0.10, we calculated a minimum sample size of 236 patients to achieve a 95% confidence interval. Univariate comparisons of baseline parameters were conducted using the unpaired *t*-test after confirming normal distribution. Non-parametric data was assessed using the Mann-Whitney U test, while categorical data was analysed using the Chi-squared or Fisher's exact test. We set statistical significance at a P value of < 0.05.

RESULTS

We compared 746 AIACs with 2126 CCs, which were conducted by seven endoscopists, comprising four gastroenterologists and three surgeons. Patient demographics were similar between patients undergoing AIAC and CC at baseline, with a median age of 60 years (interquartile range 49-70) and a slight female predominance of 52.1% (Table 1). Procedure indications in order of frequency were symptoms (35.1%), surveillance following previous polyps (31.2%) and investigation of a positive faecal occult blood test (14.8%). The indication for the procedure, quality of bowel prep and caecal intubation rates were well matched between the study populations (P > 0.05).

AIAC introduction ultimately had no significant impact on either ADR (52.1% for AIAC *vs* 52.6% for CC, P = 0.91) or SSLDR (17.4% for AIAC *vs* 18.1% for CC, P = 0.44) on an institutional level. However, a per-proceduralist analysis (Figure 1) demonstrated a significant change for two endoscopists, with ADR increasing by 16.8% for one (CC 61.4%, AIAC 78.2%, P = 0.004) and decreasing by 21% for another (CC 58.6%, AIAC 37.6%, P = 0.006). By-proceduralist analysis of SSLDR did not yield significant results. The AIAC group exhibited a longer mean withdrawal time (13 min 18 sec) compared with the CC group (12 min 29 sec), though this different was not statistically significant (P = 0.48) (Figure 2). Analysis by adenoma or sessile serrated lesion (SSL) size was not significant between groups, with the majority of adenomas detected being < 5 mm in size in both groups (Figure 3).

DISCUSSION

We demonstrate that AI in colonoscopy yielded no benefit in our unit and failed to improve either ADR or SSLDR. One possible explanation for our experience being discordant to trial data is that the baseline ADR of 52% in our unit is substantially higher than many of the published RCTs to date, and there may be a ceiling effect to polyp detection among high performing endoscopists. Furthermore, results from RCTs may be overly optimistic as proceduralists were not blinded to the intervention, which may have impacted their performance and prompted a more thorough mucosal exposure or conscientious lesion assessment[8]. A more concerning explanation would be that CADe instilled a false sense of security and unwittingly resulted in a degradation of mucosal exposure quality, though a consistent withdrawal time would argue against this. It is also possible that proceduralists did not utilize CADe to the full extent and ignored lesions highlighted by CADe because they either deemed these to be clinically unimportant or incorrectly believed them to be false-positive signals. As such, exploration of endoscopist attitudes and behavior in the face of a nascent technology and formal training in CADe may be critical for successfully integrating AIAC across a range of practice settings.

Interestingly, per-proceduralist analysis of ADR yielded significant results for two individuals, including one interventional gastroenterologist whose ADR deteriorated with AIAC. Given the comparatively short period of observation of AIAC compared with CC, this may reflect a type II error due to the smaller number of AIAC procedures or alternatively stem from an altered referral pattern during this limited time period. Again, there was no change in withdrawal time to suggest a degradation in examination quality due to overreliance on AI. In terms of SSL detection, these are known to be more challenging to detect given they are often located in the proximal colon and have a non-polypoid configuration with inconspicuous borders[9]. There has been no substantial improvement in SSLDR in the majority of published AIAC studies except for two tandem colonoscopy RCTs which demonstrated reduced SSL miss rates with AIAC, although detection rates compared unfavorably with our 18% baseline SSLDR[10,11].

Our study is not an outlier, but rather follows a series of recent disappointing results from AIAC implementation in high-performing Western endoscopy units that challenge the generalizability of the benefits of CADe demonstrated in early RCTs across broader clinical settings. Most notably, Wei *et al*[12] performed a multi-center RCT across four community-based endoscopy centers in the United States and found no change in the number of adenomas per colonoscopy (0.73 for AIAC *vs* 0.67 for CC, P = 0.496) or the ADR (35.9% for AIAC *vs* 37.2% for CC, P = 0.774). This study is particularly salient as it offered a more pragmatic trial design, allowing proceduralists to choose how they employed the AI assistance mode (*i.e.* 'on' during insertion or only once the cecum was reached). Similarly, a United Kingdom RCT found that AIAC resulted in a higher polyp detection rate (85.7% for AIAC *vs* 79.7% for CC; P = 0.05) but no change in ADR (71.4% for AIAC *vs* 65.0% for CC, P = 0.09)[13]. Furthermore, a large volume endoscopy center in Israel retrospectively demonstrated a deterioration in ADR with AIAC implementation (30.3% for AIAC *vs* 35.2% for CC, P < 0.001)[14]. While there are challenges to comparing results of different CADe systems across various clinical settings,

Table 1 Baseline patient demographics, procedure characteristics and detection rate for both conventional colonoscopy and Artificial Intelligence Assisted Colonoscopy

	AIAC (*n* = 746)	CC (*n* = 2162)
Age, median (IQR)	58.2 (47-69)	60 (49-71)
Sex		
Male	359 (48.1)	1034 (47.8)
Female	387 (51.9)	1128 (52.2)
Indication for colonoscopy		
Symptoms	292 (39.1)	729 (33.7)
Surveillance	201 (26.9)	706 (32.7)
Positive FOBT	128 (18.5)	293 (13.6)
Other	125 (16.8)	434 (20.1)
Bowel Prep Quality		
Not stated	0 (0)	1 (0.05)
Poor	39 (5.2)	107 (4.9)
Fair	101 (13.5)	225 (10.4)
Good	514 (68.9)	1582 (73.2)
Excellent	92 (12.3)	247 (11.4)
Caecum intubated	733 (98.3)	2104 (97.3)
Withdrawal time (min), median (IQR)	13.31 (9.13-19.06)	12.49 (8.38-19.0)
PDR	620 (85.3)	1596 (73.9)
Polyps removed		
0	176 (23.6)	566 (26.2)
1	126 (16.9)	446 (20.6)
2	99 (13.3)	325 (15.0)
3	81 (10.9)	216 (10.0)
4	57 (7.6)	128 (5.9)
5	52 (7.0)	118 (5.5)
6	35 (4.7)	84 (3.9)
7	29 (3.9)	62 (2.9)
8	18 (2.4)	38 (1.8)
9	12 (1.6)	33 (1.5)
10-19	52 (7.0)	129 (6.0)
20-99	9 (1.2)	17 (0.8)
Adenoma detection rate	392 (52.6)	1125 (52.1)
Villous histology	26/392 (6.6)	80/1125 (7.1)
HGD	2.3/392 (9.0)	43 (3.8)
Adenomas removed		
0	354 (47.5)	1037 (48.0)
1	167 (42.6)	478 (42.5)
2	74 (18.9)	232 (20.6)
3	39 (10.0)	138 (12.3)
4	31 (7.9)	88 (7.8)

5	22 (5.6)	69 (6.1)
6	15 (3.8)	33 (2.9)
7	10 (2.5)	32 (2.8)
8	12 (3.06)	22 (2.0)
9	5 (1.3)	11 (1.0)
10-19	17 (4.3)	20 (1.8)
20-99	0 (0)	2 (0.2)
Adenoma size		
≤ 5 mm	234 (59.7)	683 (60.7)
5-10 mm	101 (25.8)	269 (23.9)
10-20 mm	49 (12.5)	126 (11.2)
≥ 20 mm	8 (2.0)	47 (4.2)
SSLDR	130 (17.4)	392 (18.1)
SSLs with Dysplasia	1 (0.7)	3 (0.7)
SSLs removed		
1	65 (50)	211 (53.8)
2	34 (26.2)	86 (21.9)
3	12 (10)	27 (6.9)
4	4 (3.1)	16 (4.1)
≥ 5	12 (10.8)	52 (13.2)
SSL size		
≤ 5 mm	58 (44.6)	173 (44.1)
5-10 mm	43 (33.1)	118 (30.1)
10-20 mm	23 (17.7)	92 (23.5)
≥ 20 mm	6 (4.6)	9 (2.3)

Data are presented as median (IQR) or number of patients (% of patients). AIAC: Artificial Intelligence Assisted Colonoscopy; CC: Conventional colonoscopy; FOBT: Fecal Occult Blood Test; IQR: Interquartile range; PDR: Polyp detection rate; HGD: High grade dysplasia; SSLDR: Sessile serrated lesion detection rate; SSL: Sessile serrated lesion.

these studies highlight that real-world CADe implementation without attention to the AI-human interaction may fail to achieve intended outcomes.

Withdrawal time is a key marker of colonoscopy quality that is strongly correlated with ADR[15]. In our study, withdrawal time did not change, though our median of 12.82 min for CC significantly exceeds the grouped averages for controls in early RCTs which ranged from 4.76 min to 6.99 min[6]. In these RCTs, improvements in ADR with CADe have paralleled increases in withdrawal time. Similarly, a New Zealand center demonstrated increased ADR with AIAC deployment (47.9% for AIAC *vs* 38.5% for CC; P = 0.03), though the AIAC group also had a significantly longer withdrawal time (15 min for AIAC *vs* 13 min for CC; P < 0.001)[16]. Arguably, ADR improvements could therefore merely be the result of a more thorough examination, reflected in the longer withdrawal time, rather than AI. Notably, in the study by Wei *at al*[12], ADR did not improve despite a prolonged withdrawal time in the AIAC group, possibly reflecting increased time spent assessing activations from the AI module, including possible false positives.

Even though polyp size was comparable between groups in our study, it is worth noting that improvements in ADR with AI in previous RCTs have primarily been driven by an increased in the detection of diminutive adenomas of 5 mm in size or lower[6]. In our study, adenomas < 5 mm constituted 60.7% of resected adenomas in the control group, compared with a mean of 19% in RCT controls[6]. Coupled with high baseline ADRs and SSLDRs in our unit, this likely reflects astute mucosal exposure and examination in our institution. Furthermore, the merit of increased detection and removal of diminutive polyps is a point of controversy, particularly with respect to the degree this mitigates cancer risk [17].

A significant strength of our study is its real-world setting, which confers less risk of operator bias than a trial framework. Important limitations include the retrospective design, relatively short period of observation for AIAC and lack of patient randomization, though enrollment of consecutive patients resulted in well-matched baseline characteristics. Furthermore, the CADe mode could be switched on and off by proceduralists at their discretion, generating a

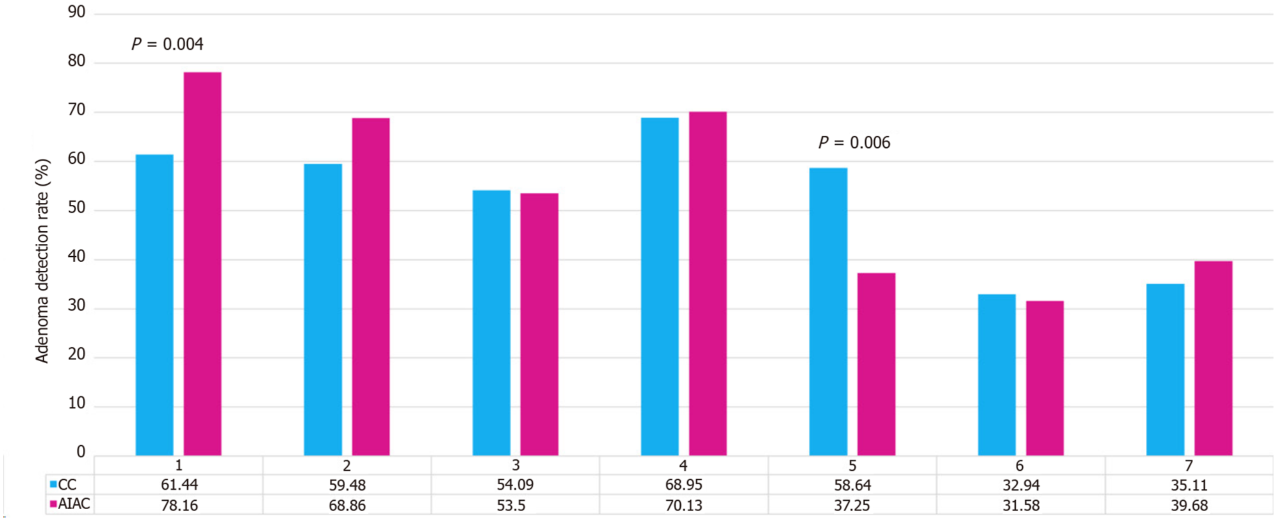

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Figure 1 By-proceduralist analysis of adenoma detection rate for both conventional colonoscopy and Artificial Intelligence Assisted Colonoscopy. CC: Conventional colonoscopy; AIAC: Artificial Intelligence Assisted Colonoscopy.

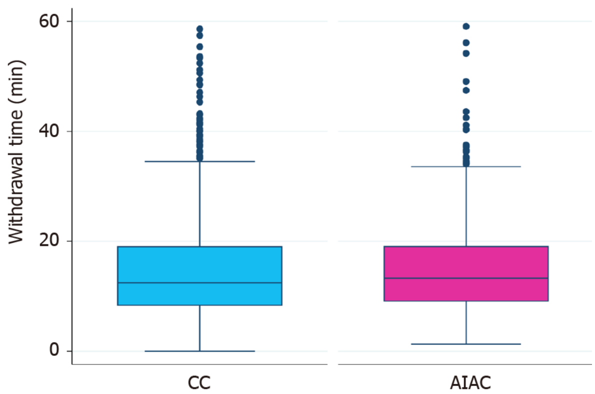

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Figure 2 Median withdrawal time for both conventional colonoscopy and Artificial Intelligence Assisted Colonoscopy. CC: Conventional colonoscopy; AIAC: Artificial Intelligence Assisted Colonoscopy.

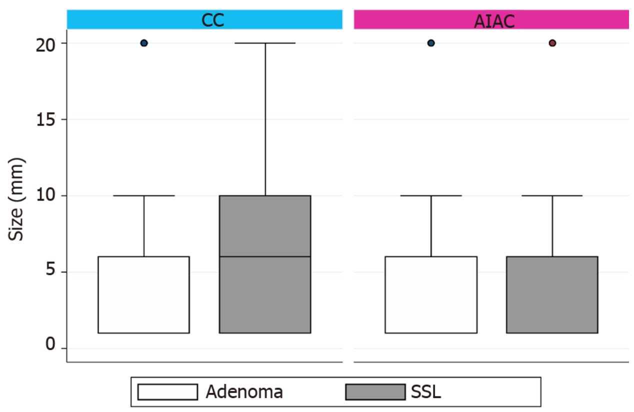

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Figure 3 Median adenoma and sessile serrated lesion size (mm) for both conventional colonoscopy and Artificial Intelligence Assisted Colonoscopy. CC: Conventional colonoscopy; AIAC: Artificial Intelligence Assisted Colonoscopy; SSL: Sessile serrated lesion.

further variable of "on time" for CADe, which was not documented. In addition, though intuitive, no formal training was provided for CADe prior to implementation.

CONCLUSION

Ultimately, while AIAC has shown promise in early RCTs, further validation is required to assess its effectiveness and cost-efficiency in institutions with high performance metrics at baseline, where gains from AI are likely to be far more incremental. Specifically, longitudinal studies that assess the impact of AIAC on interval cancer rates are required. Beyond CADe, additional applications of AI in colonoscopy may increase its utility. For example, the development of computer-assisted diagnosis, which promises to confidently distinguish diminutive hyperplastic polyps from neoplastic lesions through optical pathology, could lead to significant cost-savings by allowing proceduralists to adopt a 'resect and discard' policy rather than sending these specimens for histopathology[18]. Similarly, novel AI systems can recognize key endoscopic landmarks, specific tools, and quality of bowel preparation and integrate this information into an automatically generated colonoscopy report, reducing peri-procedural documentation burden[19]. As such, it may be that a comprehensive suite of AI tools is necessary to fully realize the benefits in this field.

ARTICLE HIGHLIGHTS

Research perspectives

While Artificial Intelligence Assisted Colonoscopy (AIAC) has shown promise in early randomised controlled trials (RCTs), further validation is required to assess its utility and cost-effectiveness in centres with high baseline performance metrics, where gains from artificial intelligence (AI) are likely to be far more incremental. Specifically, longitudinal studies that assess the impact of AIAC on interval cancer rates are required.

Research conclusions

In our institution, introduction of AIAC failed to improve key benchmarks of colonoscopy quality, including adenoma detection rate (ADR), sessile serrated lesion detection rate (SSLDR) and withdrawal time. An important limitation of our investigation is the relatively brief observation period following AIAC implementation, that the ‘on time’ of the AI assistance mode was not recorded as well as the retrospective design.

Research results

The study included 746 AIAC procedures and 2162 conventional colonoscopy (CC) procedures performed by seven endoscopists. Baseline patient demographics were similar, with a median age of 60 years and a slight female predominance (52.1%). Procedure indications, bowel preparation quality, and caecal intubation rates were comparable between groups. AIAC had a slightly longer withdrawal time compared to CC, but the difference was not statistically significant. The introduction of AIAC did not significantly change ADR (52.1% for AIAC *vs* 52.6% for CC, P = 0.91) or SSLDR (17.4% for AIAC *vs* 18.1% for CC, P = 0.44).

Research methods

This retrospective observational cohort study was conducted at a single center in Brisbane, Australia, encompassing all patients who underwent colonoscopy during the study period. Colonoscopy quality markers for CCs conducted from October 2021 to October 2022 were compared with AIAC markers following the implementation of the Olympus Endo-AID module from October 2022 to January 2023. Proceduralists who conducted over 50 procedures before and after AIAC introduction were included. Procedures for surveillance of inflammatory bowel disease were excluded. Patient demographics, proceduralist specialisation, indication for colonoscopy, and colonoscopy quality metrics were collected. We determined the ADR and SSLDR for both CC and AIAC.

Research objectives

The objective of our investigation was to assess the effect of AIAC on key benchmarks of colonoscopy quality including the detection rate of adenomas (ADR) and SLLDR as well as withdrawal time in comparison to CC.

Research motivation

In recent years, rapid technological advancements and a focus on quality improvement have garnered significant enthusiasm for AIAC as a means of improving key markers of colonoscopy quality. While early data appears promising, this technology requires validation in day-to-day clinical practice.

Research background

AIAC has emerged as a potential tool for improving colonoscopy quality and mitigating factors such as proceduralist fatigue or inattention in a procedure that is substantially operator dependent. However, published data on the utility and cost-effectiveness in real-world clinical settings is limited.

FOOTNOTES

Author contributions: All authors conceived the idea. KH collated the data from the departmental database; Goetz N performed the statistical analysis and was primarily responsible for writing the manuscript; Cheng RKY provided substantial revisions to the manuscript.

Institutional review board statement: The study was approved by the local Human Research Ethics Committee (HREC/2023/MNHA/100582).

Informed consent statement: A waiver of consent was obtained from the HREC.

Conflict-of-interest statement: The authors declare there is no potential sources of conflict of interest. This study was not funded, with research work conducted *in-kind*.

Data sharing statement: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

STROBE statement: The authors have read the STROBE Statement – checklist of items, and the manuscript was prepared and revised according to the STROBE Statement – checklist of items.

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