Diagnostic performance of computed tomography colonography following incomplete colonoscopy and its associated factors: A single-centre retrospective study

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ABSTRACT

Introduction: Incomplete colonoscopy presents an important clinical challenge, as segments of the colon that are not visualised may contain significant pathology. Computed tomography colonography (CTC) provides a minimally invasive alternative for comprehensive luminal evaluation, but local evidence regarding its diagnostic yield remains limited. This study aimed to evaluate the diagnostic yield of CTC following incomplete colonoscopy and to determine its associated factors with demography.

Materials and Methods: A retrospective cohort study was conducted among 93 adult patients who underwent CTC after incomplete colonoscopy between 2018 and 2023 at Hospital Tengku Ampuan Afzan, Kuantan. Patient demographics, prior surgical history, CTC findings and lesion characteristics were analysed using descriptive statistics, Chi-square and Fisher's exact tests.

Results: CTC demonstrated a diagnostic yield of 21.5%. In this cohort, females accounted a 58.1% of the population. Polyps were the most frequent pathology, followed by diverticulosis, segmental wall thickening, and a single case of colorectal mass. Statistical analysis showed no significant association between abnormal findings and demographic factors such as age, gender, ethnicity, previous abdominal surgery, clinical indications, or most proximal colonoscopic intubation (p >0.05). Although statistical significance was not significant, abnormalities were more often detected in older patients and when colonoscopic intubation was confined to the rectosigmoid colon.

Conclusion: CTC detected clinically important finding in more than one-fifth of patients, reconfirming its role as a valuable adjunct when colonoscopy is incomplete. These results showed polyps and diverticulosis as the main abnormalities with no clear predictors from patient factors. Larger prospective studies are needed to refine patient selection and optimise imaging quality in local setting.

KEYWORDS:
Computed Tomographic Colonography; Colonoscopy; Diverticulosis; Polyps

INTRODUCTION

Colorectal cancer remains a significant global health concern, ranking as the third most common malignancy and a leading cause of cancer-related mortality.[1] In Malaysia, it falls into the number two cause of cancer mortality.[2] Early detection and intervention through screening programs, particularly colonoscopy, have been instrumental in reducing incidence and improving patient outcomes.[3] However, colonoscopy, despite being the gold standard for colorectal cancer detection, is an invasive procedure associated with risks such as bowel perforation and bleeding, and it may not always achieve complete colonic visualization.[4] In cases of incomplete colonoscopy, where the caecum is not reached, a significant portion of the colon may remain unexamined, potentially missing critical lesions with a reported failure rates range from 4% to 25%.[5,6] Moreover, data from earlier research have demonstrated that a significant adenoma missing rates differences by size (36%, adenomas 1–5 mm; 27%, adenomas 6–9 mm; 12%, adenomas ≥ 10 mm), histology (non-advanced: 42%, advanced: 21%) and morphology (flat: 50%, polypoid: 27%).7 Factors such as patient discomfort, sharp angulation, strictures, looping, adhesions, diverticulosis, redundant colon, poor bowel preparation and anatomical variations can prevent full insertion of the colonoscope.[5]

This scenario necessitates alternative imaging modalities to ensure complete colonic evaluation and mitigate the risk of delayed diagnosis.[8] Computed tomography colonography (CTC) has emerged as a robust, less invasive alternative for visualizing the entire colon, particularly after an incomplete optical colonoscopy.[9] CTC offers a comprehensive luminal assessment, identifying polyps and masses that might otherwise be overlooked, thereby contributing to earlier diagnosis and improved patient management.[10] Moreover, the non-invasive nature and relative safety of CTC, coupled with its high diagnostic accuracy for significant colonic neoplasia, make it an increasingly attractive option for colorectal cancer screening and surveillance, especially for patients who are unable or unwilling to undergo conventional colonoscopy.[11,12] Furthermore, CTC can assess extraluminal structures, providing additional diagnostic information that is not available with colonoscopy, which is crucial for colorectal cancer staging.[13,14] This capability allows for the identification of metastatic disease and provides a more complete picture of disease burden, informing critical treatment decisions.[15]

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While the diagnostic accuracy of CTC is well-supported internationally, its clinical performance remains highly context-dependent.16 Hospital Tengku Ampuan Afzan, as a public tertiary centre serving a diverse population in Malaysia's East Coast region, operates within healthcare delivery systems, infrastructure, and patient profiles that may differ significantly from those in global studies. Despite the growing relevance of CTC following incomplete colonoscopy, local data—especially within Malaysian government hospitals—remain scarce. Given the prevalence of colorectal cancer and the challenges associated with incomplete colonoscopy, understanding the local diagnostic utility of CTC is paramount for optimizing patient care and resource allocation within the Malaysian healthcare system. This study was conducted to address the limited local data on CTC by assessing its diagnostic performance and identifying factors associated with abnormal or inadequate outcomes.

MATERIALS AND METHODS

This retrospective cohort study was conducted at Hospital Tengku Ampuan Afzan, Kuantan, and included all adult patients who underwent CTC following an incomplete colonoscopy between January 2018 and December 2023. Inclusion criteria encompassed patients aged 18 years or older with documented incomplete colonoscopy, while patients with contraindications to CTC, prior history of colorectal surgery or diagnosed colorectal cancer, those with poor-quality CTC images rendering interpretation unreliable, and patients who were either lost to follow-up or failed to complete the recommended diagnostic or therapeutic procedures following CTC were excluded from the analysis. Patients with incomplete medical records were excluded to maintain data integrity. The study protocol received ethical approval from the Medical Research and Ethics Committee, Ministry of Health Malaysia (NMRR-25-03001-VA9), ensuring adherence to ethical guidelines for retrospective data analysis.

The dataset, obtained from institutional records unit was reviewed and analysed in accordance with ethical standards and anonymised study procedures. Consent was not required due to the retrospective nature of the study and the use of deidentified patient data. Clinical variables collected included age, gender, ethnicity, history of previous abdominal surgery and CTC findings as well as lesion characteristics including radiological reports and endoscopy notes. Each CTC examination was performed according to standardized protocols, involving bowel preparation with polyethylene glycol and subsequent insufflation of carbon dioxide. Reconstructions including 2D axial, coronal, and sagittal images, along with 3D volumetric renderings, were generated and interpreted by experienced radiologist. Imaging results were categorised as normal, inadequate or abnormal. Abnormal findings were further subclassified into polyps, diverticulosis, segmental wall thickening or colorectal masses. The primary outcome measure was the diagnostic yield of CTC, defined as the proportion of abnormal imaging reports among all CTC studies performed. Secondary outcomes included lesion distribution and potential associations between abnormal findings and patient-related factors.

Statistical analysis was performed using SPSS version 30. Descriptive statistics were used to summarise patient characteristics and imaging findings. Categorical variables were compared using Chi-square or Fisher's exact test as appropriate, with a p-value <0.05 considered statistically significant.

RESULTS

The data summary of the population studied is summarized in Table I. A total of 93 patients underwent CTC following incomplete colonoscopy during the study period. The commonest age group that underwent CTC was from age of 60-69 years old (28.0%) followed by age group 70 and above (25.8%). The mean age of approximately 60.4 years (±11.9). Females represented a slight majority, accounting for 58.1% of the population. In terms of ethnic distribution, the majority were Malay (50.5%), followed by Chinese (39.8%) and Indian (8.6%), which aligns with regional demographics in Pahang. Notably, 9.7% of patients had a history of previous abdominal surgery, while 88.2% reported no such history. These demographic features provide context for interpreting diagnostic trends and may influence factors such as bowel preparation quality and colonic angulation, which are relevant in assessing the utility of CTC following incomplete colonoscopy.

Most scans were either normal (38.7%) or inadequate (39.8%), while 21.5% demonstrated abnormal findings, corresponding to a diagnostic yield of just over one-fifth. Among those with abnormal findings, polyps were the most identified lesions, accounting for 45% of cases. Diverticulosis was identified in 40% of abnormal scans, while segmental wall thickening was detected in 10%. Only one patient (5%) had a colorectal mass suggestive of malignancy. The following figures show various positive findings (Figure 1) and inadequate CTC (Figure 2) during CTC.

Based on the analysis of the CTC data from Hospital Tengku Ampuan Afzan, no statistically significant associations were found between patient demographics and abnormal CTC findings (Table II) namely polyps, diverticulosis, segmental wall thickening, or colonic mass. Although abnormalities were more frequently seen among older patients (notably in the 50–69 age group), this trend did not reach statistical significance ($p=0.741$). Similarly, the distribution of abnormalities did not differ significantly by gender ($p=0.242$) or ethnicity ($p=0.349$), though Chinese patients accounted for a proportionally higher number of diverticular findings. Prior abdominal surgery and clinical indications for CTC also showed no meaningful association with abnormal outcomes ($p=0.553$ and $p=0.810$, respectively). Interestingly, although not statistically significant, most abnormal findings were seen in patients whose colonoscopy reached only the rectosigmoid region, suggesting that limited initial scope access may slightly increase diagnostic yield from CTC ($p=0.077$).

The subsequent management of patients with abnormal CTC findings (Figure 3) demonstrated a range of clinical pathways and outcomes. The single case of colonic mass was further evaluated with colonoscopy, confirmed as descending colon adenocarcinoma, and treated with subtotal colectomy.

Table I: Patients' demographics

Variables	N (%)
Age	
18 – 29 years old	7 (7.5)
30 – 39 years old	4 (4.3)
40 – 49 years old	12 (12.9)
50 – 59 years old	19 (20.4)
60 – 69 years old	26 (28.0)
70 and above	24 (25.8)
Gender	
Male	39 (41.9)
Female	54 (58.1)
Ethnicity	
Malay	47 (50.5)
Chinese	37 (39.8)
Indian	8 (8.6)
Previous abdominal surgery	
Yes	9 (9.7)
No	82 (88.2)
Indication for CTC	
Change in bowel habit	21 (22.6)
Per rectal bleeding	20 (21.5)
Positive faecal occult blood test	15 (16.1)
Abdominal pain	14 (15.1)
Constipation	12 (12.9)
Others	11 (11.8)
Most proximal intubation	
Rectosigmoid	46 (49.5)
Descending colon	9 (9.7)
Transverse colon	3 (3.2)
Ascending colon	1 (1.1)
Hepatic flexure	12 (12.9)
Splenic flexure	22 (23.7)
CTC findings	
Inadequate	37 (39.8)
Normal study	36 (38.7)
Abnormal	20 (21.5)
Abnormal CTC Findings	
Colonic polyps	9 (9.7)
Diverticulosis	8 (8.6)
Segmental wall thickening	2 (2.2)
Colonic mass	1 (1.1)

Among patients with polyps (n=9), five underwent follow-up colonoscopy, which revealed benign findings in three cases, diverticulosis in one, and normal findings in one, while the remaining four were managed with clinical surveillance. Both cases of segmental wall thickening (n=2) proceeded to colonoscopy, showing normal findings in one and diverticulosis in the other. All patients with diverticulosis (n=8) were managed conservatively with symptom monitoring and follow-up. These findings reflect the variability in downstream management and confirmatory outcomes following abnormalities detected on CTC.

DISCUSSION

This study demonstrates that CTC provided clinically useful diagnostic information in 21.5% of patients who had incomplete colonoscopy, aligning with international literature where reported yields up to 22.9%.[17] For instance, a review of CTC applications reported neoplasia in 19% of patients, with polyps greater than 1 cm in 7.7% and smaller polyps in 5.7%.[18] This yield is further supported by findings from a clinical screening program which noted a 14.3% overall positive rate at CTC, with 85.0% negative and 0.7% non-diagnostic rates.[19] These findings are consistent with prior research indicating that CTC is effective in detecting colorectal polyps, with diagnostic yields comparable to those previously reported in the literature.[20] Most abnormalities detected were colonic polyps and diverticulosis, reinforcing prior evidence that CTC performs reliably in identifying such structural lesions, particularly in the segments of the colon not reached during endoscopy. For example, meta-analyses evaluating CTC and second-generation capsule colonoscopy on incomplete colonoscopies reported diagnostic yields of 13% for polyps greater than 5 mm and 4% for those exceeding 9 mm, specifically for CTC.1 Moreover, research indicates that CTC can detect polyps with high sensitivity and specificity, making it a valuable tool for surveillance in patients with incomplete colonoscopies.[17]

Over half of the patients in this cohort were aged 60 and above, and a higher proportion were female - the demographics commonly seen in colorectal cancer screening populations.[21] This age group is more likely to experience incomplete colonoscopy, often due to anatomical challenges such as tortuous or elongated colon segments and the presence of diverticular disease, particularly affecting the

Table II: Associations between demography and abnormal findings.

Variables	CT Findings			p-value
	Inadequate	Normal	Abnormal	
Age				0.768[a]
18 – 29 years old	2	4	1	
30 – 39 years old	0	3	1	
40 – 49 years old	5	5	2	
50 – 59 years old	6	7	6	
60 – 69 years old	12	9	5	
70 and above	12	8	4	
Gender				0.893[b]
Male	16	14	9	
Female	21	22	11	
Ethnicity				0.259[a]
Malay	22	18	7	
Chinese	13	15	9	
Indian	2	2	4	
Previous abdominal surgery				0.591[a]
Yes	3	3	3	
No	34	33	15	
Indication for CTC				0.624[a]
Change in bowel habit	7	9	5	
Per rectal bleeding	7	10	3	
Positive faecal occult blood test	8	6	1	
Abdominal pain	6	3	5	
Constipation	3	5	4	
Others	5	3	2	
Most proximal intubation				0.214[a]
Rectosigmoid	22	12	12	
Descending colon	2	5	2	
Transverse colon	2	1	0	
Ascending colon	0	0	1	
Hepatic flexure	5	5	2	
Splenic flexure	6	13	3	

a Fisher's exact test
b Pearson's chi-square test

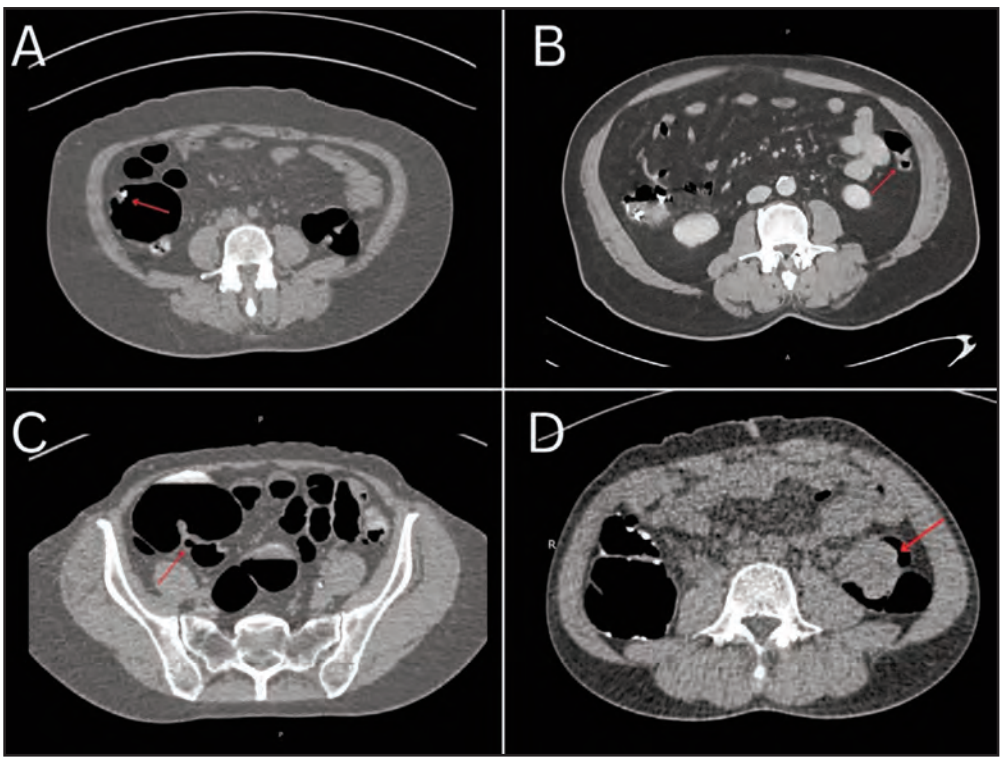

Fig. 1: (A) A case with colonic polyp (red arrow). (B) A case with descending colon thickening (red arrow). (C) A case with colonic diverticulum (red arrow). (D) A case with descending colon mass (red arrow).

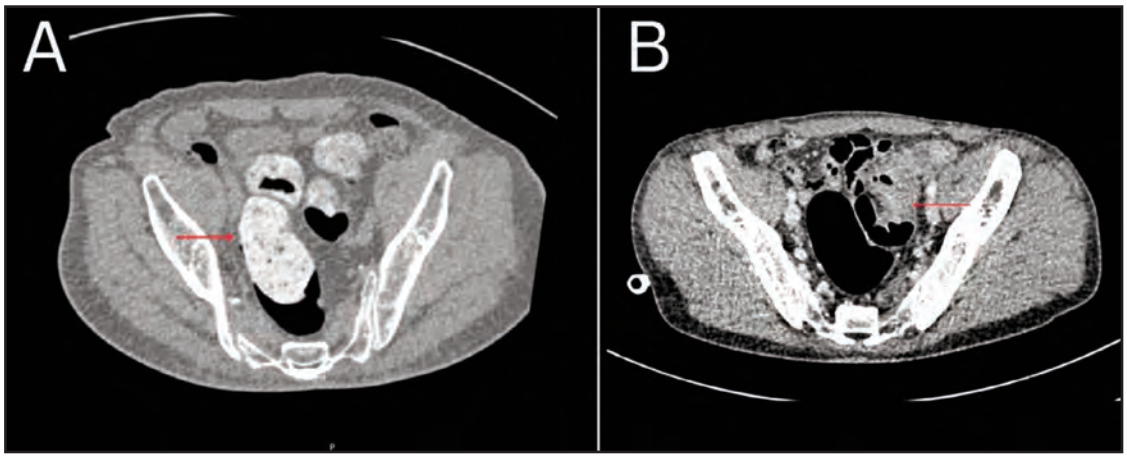

Fig. 2: (A) A case with residual solid stool (red arrow) in the rectosigmoid colon due to poor bowel preparation. (B) A case with segmental under-distension mimicking wall thickening (red arrow)

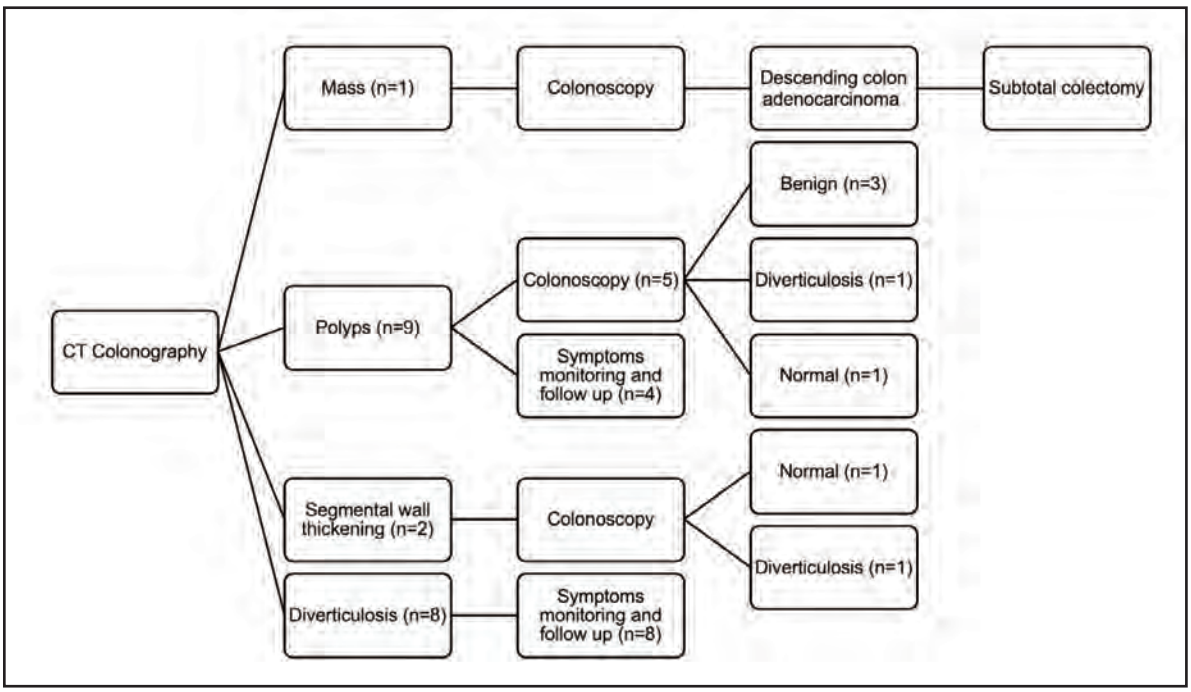

Fig. 3: Clinical pathways and outcomes of abnormal findings detected on CTC

proximal colon, which can remain unexamined during standard procedures.[10,22] The predominance of female patients also reflects established findings that women tend to have higher rates of incomplete colonoscopy, influenced by narrower pelvic anatomy or surgical adhesions from prior abdominal operations.[23] While previous abdominal surgery may contribute to procedural difficulty, our analysis did not show a statistically significant association between such history and abnormal CTC findings in this group. Nonetheless, these demographic patterns support the continued role of CTC as a practical adjunct, particularly in older or female patients, where complete endoscopic evaluation is frequently limited.[21]

The study cohort was largely made up of Malay patients, followed by those of Chinese and Indian ethnicity, a distribution that mirrors the population makeup of Pahang. While representative of the local demographic landscape, this composition contrasts with national data showing higher rates of colorectal cancer among Chinese and Indian populations in Malaysia.[19,24] This discrepancy is important, as the background risk of colorectal pathology may vary across ethnic groups and, in turn, influence the diagnostic yield of CT colonography. Recognising these differences is crucial when interpreting imaging outcomes in heterogeneous populations. Therefore, future efforts to improve colorectal cancer screening strategies should integrate ethnic-specific epidemiological insights to enhance diagnostic precision and ensure equitable care delivery.[25,26]

Despite widespread awareness of the technical causes behind inadequate CTC – such as poor bowel preparation, ineffective

faecal tagging, and insufficient colonic distention—these issues remain persistent, even in institutions with established imaging protocols. Their recurrence points not only to technical oversights but to a broader need for consistent execution and better system integration. Tackling these challenges calls for more than reiterating standard instructions. Instead, centres should consider implementing structured audit-and-feedback systems to identify recurring inadequacies, assigning dedicated staff to monitor prep compliance, and adopting risk-stratified bowel prep regimens. Radiographer credentialing and continuous technical training may also help raise the baseline quality of image acquisition. Enhancing patient education, particularly with visual aids or mobile reminders, can improve compliance, while newer solutions such as AI-supported post-processing may help mitigate the effects of residual stool or poor distension on image interpretation.[17] Together, these targeted and patient-centred strategies offer a more accountable and responsive approach to improving CTC quality at the institutional level.

Incomplete colonoscopy continues to present a significant clinical challenge, particularly when anatomical factors such as marked diverticulosis or a tortuous colon impede the passage of the endoscope.[14–16] These anatomical barriers frequently necessitate alternative imaging solutions like CTC to ensure full colonic evaluation beyond the reach of conventional endoscopy. In this study, nearly 40% of CTCs were found to be technically inadequate, a rate substantially higher than the commonly cited 5–10% in the literature.[17] This disparity points to critical gaps in current practices, especially in bowel preparation quality, faecal tagging adequacy, and technical consistency during scanning. It underscores the need to refine preparation protocols and improve imaging workflows for better diagnostic yield.[8] Additionally, suboptimal sedation and inadequate cleansing, especially in centres lacking anaesthetic support, remain key contributors to incomplete procedures.[18,19] Patients who experience discomfort or sedation failure are rarely re-counselled or offered a better-prepared repeat colonoscopy, leading to procedural inefficiencies. In such cases, CTC stands out as a viable, sedation-free, and patient-friendly alternative that provides comprehensive colonic assessment while easing the burden on already strained endoscopy units.[9]

The strengths of this study include its real-world clinical dataset collected over several years and its relevance to Malaysian healthcare practice. Another key strength of this study is that it shows what happens after CT colonography findings in real clinical practice, not just what is detected. It outlines how patients were managed, including repeat colonoscopy, surgery, or simple follow-up. This is especially useful in cases of incomplete colonoscopy, where decisions are often uncertain. However, limitations include the retrospective design, single-centre setting and modest sample size, which may limit generalisability. Additionally, the high proportion of inadequate CTC scans may have underestimated the true diagnostic yield. Future prospective studies with larger, multicenter cohorts are warranted to validate these findings and to evaluate strategies to improve the technical adequacy of CTC, particularly across diverse patient populations.

CONCLUSION

CTC remains a valuable imaging modality for evaluating the colon following incomplete colonoscopy and contributed to the detection of clinically relevant abnormalities in more than 20% of patients in this study. The predominance of polyps and diverticulosis among abnormal findings underscores the importance of complete colonic evaluation in preventing missed pathology. Although demographic and clinical variables did not predict abnormal CTC outcomes, these findings support the broad application of CTC in such clinical scenarios. Future multicentre prospective studies are warranted to refine patient selection, improve imaging techniques and enhance overall diagnostic performance in Malaysian clinical practice.

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