



Impact of Artificial Intelligence in Colonoscopic Polyp Detection and Classification



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Abstract

Background: Despite screening colonoscopy the relative risk for incidence and mortality of colorectal cancer is lowered by around 50 to 60% probably due to missed adenomas. Artificial intelligence is a new development to rise detection of colorectal lesions and additionally to classify them.

Methods: We performed a Pubmed research for AI in combination with ADR, PDR and characterization of colorectal lesions.

Results: AI based detection of colorectal lesions rises ADR and PDR significantly, additionally withdrawal time is controlled. Standardized classification of bowel cleansing might be helpful. Nevertheless, rise of ADR and PDR is mainly based on the detection of small lesion with questionable relevance for colorectal cancer development within the control interval. Real-time characterization of detected colorectal lesions is currently on the level of expert endoscopist.

Conclusion: AI based colorectal polyp detection improves quality of screening colonoscopy in 2021 especially in not so experienced endoscopists. Long time studies have to investigate influence on relevant outcome quality parameters especially incidence of colorectal cancer. AI based polyp characterization has currently to be improved before a leave in strategy of small benign lesions can be discussed

Keywords: Colorectal cancer; Artificial intelligence; Adenoma detection rate; Polyp detection rate; Polyp classification; Polyp characterization

Introduction

Colorectal cancer remains one of the most common of human malignancies and is responsible for 9% of deaths of malignancies worldwide [1]. Screening colonoscopy is a powerful tool preventing colorectal cancer [2]. With the widespread use of screening colonoscopy one could expect the rate of colorectal cancer dropping close to zero, but the relative risk for incidence and mortality is lowered only by around 50 to 60% [2]. Besides screening percentage and adherence to recommended screening intervals another discussed explanation are interval cancers based on missed colorectal lesions. There are several parameter which influence the adenoma and polyp detection rate including bowel preparation, time for withdrawal, second observer in unexperienced examiners, vigilance of the endoscopist, endoscopy technique including high resolution imaging, virtual chromoendoscopy and tools for detection of lesions hidden behind mucosal folds and bends [3]. All these technical improvements lead to an increase of the ADR / PDR with the limitation of visualizing

blind spots behind folds and curves. By reducing the latter, it appears almost impossible for a single endoscopist to analyze all the information in real-time.

Artificial intelligence might help to improve polyp detection automatically reducing blind spots and additionally classify these lesions. The aim of this review is to evaluate the current impact of artificial intelligence in polyp detection and characterization during the screening colonoscopy.

Methods

To evaluate the current impact of artificial intelligence in colonoscopy a literature research in Pubmed was undertaken searching for the terms "artificial intelligence" and "colonoscopy", "polyp detection", "adenoma detection", "polyp classification" and "colorectal cancer". All reviews were excluded. Out of this studies we selected studies considered valuable to be included in this work.

Results

AI and bowel preparation

The Boston Bowel Preparation score is mainly used for assessment of quality of bowel preparation. In case of insufficient bowel cleansing repetition of preparation and colonoscopy is recommended due to current guidelines [4]. Computer based documentation and classification facilitates the assessment of bowel cleansing [5]. Zhou et al. developed ENDOANGEL – a deep convolutional neural network for the assessment of bowel preparation quality. The overall accuracy was 93.3%.

AI and withdrawal time

An adequate withdrawal time leads to careful inspection and detection of a higher number polyps and adenomas. Recommended minimal time is at least 6 minutes [6]. But, there are differences between the first four colonoscopies of a day's work and all colonoscopies extending the number of nine. A study investigated that the latter are faster than the first with a decreasing PDR and ADR [7]. Artificial Intelligence might help to maintain the same

accuracy for every colonoscopy no matter when it is scheduled in the day [8]. The ENDOANGEL system was tested to control withdrawal time as well as avoiding blind spots caused by slipping of the endoscope. The withdrawal time was significantly higher using the system (6.38 vs. 4.76 min) and the adenoma detection rate doubled (16 vs 8%) [5].

AI and detection of colonic lesions

The main focus of AI is the computer based detection of colonic lesions resulting in an improvement of PDR and ADR. There are a few deep learning systems already commercially available that improve both by 21 to 75 percent for the ADR and 31 to 57 percent for the PDR (Table 1). Nevertheless the increase in the detection rate is based mainly on small lesions of 6 mm and below, the ones behind the folds, the flat lesions and the ones on the outer fields of sight [9-15]. Bigger lesions are diagnosed by either AI or an experienced endoscopist as well. Currently the impact of AI on the rate of interval carcinoma as a crucial clinical end point is not yet investigated.

Table 1: Adenoma and polyp detection rates of an artificial intelligence using system in comparison with conventional colonoscopy.

	Study Design	AI	Control	Improvement	Withdrawal Time Without Polypectomy (min) (AI/control)
Study					
Su et al. [9]	RCT				n.a.
ADR		0.289	0.165	75%	
PDR		0.383	0.254	51%	
Polyps <6mm		71%	74%		
Liu et al. [10]	RCT				6.71/6.62
ADR		0.29	0.209	39%	
PDR		0.471	0.333	41%	
Polyps <6mm		85%	73%		
Wang et al. [11]	RCT				6.18/6.07
ADR		0.291	0.203	43%	
PDR		0.45	0.291	54%	
Polyps <6mm		80%	74%		
Wang et al. [12]	RCT				6.48/6.37
ADR		0.34	0.28	21%	
PDR		0.52	0.37	40%	
Polyps <6mm		81%	74%		
Repici et al. [13]	RCT				7.3/7.0
ADR		0.548	0.404	35%	
PDR		0.747	0.57	31%	
Polyps <6mm		61%	65%		
Luo et al. [14]	RCT				6.2/6.2
PDR		0.7	0.533	31%	
Polyps <6mm		87%	86%		

Liu et al. [15]	RCT				6.2/6.1
ADR		0.27	0.216	25%	
PDR		0.401	0.283	41%	
Polyps <6mm		78%	68%		

AI and characterization of colorectal lesions

Especially in unexperienced endoscopists a computer aided diagnosis of polyp histology distinguishing between a hyperplastic polyp, non-neoplastic adenoma and a neoplastic adenoma would be helpful. Colorectal polyps are currently classified due to lesion morphology (Par's classification) [16] and using image enhanced endoscopy and virtual chromoendoscopy due to surface and vessel pattern structure (e.g. Nice and JNET classification) for discrimination of hyperplastic and adenomatous lesions [17,18]. Structure and vessel changes allow a differentiation of non-

neoplastic and neoplastic adenomas. Several studies investigated AI for characterization of colorectal polyps based on white light images, virtual chromoendoscopy with or without magnifying and pit pattern and vascularization features, table 2 summarizes the recent studies. The studies are heterogeneous concerning the image modalities used and their classification targets. Therefore, the results are differing with an sensitivity, specificity and negative predictive value ranging from 80 to 96%, 30 to 95% and 69 to 97% [19-23]. AI seems to be equivalent to expert endoscopist and appears to be advanced to beginners.

Table 2: Classification of hyperplastic polyps, adenomas and cancer by AI and endoscopists.

Study	Study Type	Classification Target	Image Modality	Accuracy	Sensitivity	Specificity	NPV
Kominami Y et al. [24]	Prospective	Non neoplastic vs neoplastic (Histology)	Magnifying NBI	0.94	0.95	0.93	0.93
Chen et al. [20] ¹	Retrospective	Neoplastic vs hyperplastic	Magnifying NBI	0.9	0.96	0.78	0.92
Byrne et al. [21]	Retrospective	Histology of diminutive polyp	NBI video frames	0.9	0.96	0.78	0.97
Zhou et al. [22] ²	Retrospective	Adenoma vs. cancer	White light	0.83-0.96		0.85-0.98	0.93-0.97
Yang et al. [23] ^{1,2}	Retrospective		White light				
		Neoplastic vs. non neoplastic		0.79	0.95	0.3	0.69
		Advanced colorectal vs. non advanced colorectal lesions		0.87	0.8	0.91	0.87
Rodriguez-Diaz et al. [19] ¹	Prospective	Neoplastic vs. non neoplastic	Magnifying NBI		0.96	0.84	0.91
Mori et al. 2020 [25] ¹	Prospective	Neoplastic vs non neoplastic	Endocytoscopy + NBI		0.93	0.95	0.95

¹ polyps and adenoma

² Cancer and adenoma

Discussion

Guidelines recommend the repetition of screening colonoscopy if the bowel cleaning is insufficient e.g. in case of a simplified BBS score ≤ 1 which means a bad preparation with lots of stool remaining. A computer based grading of bowel preparation may be more standardized especially for the in between stages than the individual endoscopists assessment which depends on experience. The AI system Endoangel [5] was evaluated based on the assessment of 5 experienced endoscopists after a special training and the scoring was taken into account only if 3 of the 5 experts were congruent. More than 5000 images were labeled to the BBS score. The system might be helpful to compare bowel preparation quality in a more objective manner and to

evaluate the influence of bowel preparation to the ADR and PDR in intermediate phases of bowel cleansing in future studies.

The influence of withdrawal time and ADR was already proved in 2006 [6] to be at least 6 minutes. Blind spots caused by slipping during a too rapid withdrawal are likely to decrease ADR/ PDR [8]. Studies investigating AI showed a higher rate of detected polyps withdrawal time may shorten during a day's course and the more subjective sense of time with a higher stress level of the endoscopist. The study of Gong et al. using the Endoangel system demonstrated a decline of withdrawal time below 6 minutes in the control group [8]. AI might be helpful to find blind spots and raise the ADR but is it really necessary for meeting the mandatory withdrawal time? Nevertheless, if using an AI system control of

withdrawal time should be included. If not using AI it seems to be recommendable to be aware of someone's own withdrawal times during the day.

AI based detection of colorectal polyps assists the endoscopist to rise the PDR and the ADR. This is helpful – especially for beginners. Less supervision is necessary and resources are saved. Wieszczy et al. showed, that an ADR below 20% results in at least doubling risk of developing a manifest colorectal cancer within 10 years, even if no adenomas were detected in the initial colonoscopy [15]. This underlines the importance of carefully inspection during screening colonoscopy. Studies investigating AI in colorectal polyp detection (Table 1) proved a higher rate of detected polyps, albeit the majority of the higher output were small benign lesions below 6 mm with questionable relevance for cancer formation within the recommended control intervals. Clinical input of the AI systems concerning long time outcome quality e.g. lowering carcinoma incidence with screening colonoscopy is still unclear and has to be investigated in long time studies.

Future perspective would be a precise AI characterization of hyperplastic polyps, non-neoplastic and neoplastic adenoma, in the latter group preferentially distinguishing between early cancer and submucosal invading cancer. This would allow to consider a resect and discard strategy during removing of benign lesions. Moreover one could discuss about leaving small hyperplastic polyps in place [20]. Currently the data of AI based characterization of colorectal polyps are still of variable quality. Studies are using different image modalities and different classification targets and size of datasets. Negative predictive values range from 0.69 to 0.97. With further development of AI one can expect a rising differentiation quality of the systems enabling us to a virtual biopsy of e.g. hyperplastic polyps. Up to that we will continue to polyp resection and histologic work up.

Conclusion

In conclusion AI based colorectal polyp detection improves quality of screening colonoscopy in 2021 especially in not so experienced endoscopists. Standardized grading of bowel preparation and control of withdrawal time seem to be helpful. Long time studies have to investigate influence on relevant outcome quality parameters especially incidence of colorectal cancer. AI based polyp characterization has currently to be improved before a leave in strategy of small benign lesions can be discussed.

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