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Effect of different working periods on missed diagnosis of colorectal polyps in colonoscopy

Qing Xu¹ and Zhi He^{1*}

Abstract

Background To investigate the effect of different working periods on missed diagnoses in patients with colorectal polyps in colonoscopy.

Methods We conducted a retrospective analysis of patients who were diagnosed with colorectal polyps during colonoscopy in an outpatient department between July and December 2022. These patients were subsequently hospitalized for resection during this period. Patients with missed diagnoses were those who had newly discovered polyps in a second colonoscopy. The working periods were categorized as work, near the end of work, and delayed work, respectively, in the morning and afternoon.

Results A total of 482 patients were included, and the miss rate of diagnosis was 48.1% (232/482), mainly in the transverse colon (25%), and the ascending colon (23%). Patient age was a risk factor for the miss rate of diagnosis (OR = 1.025, 95%CI: 1.009–1.042, $P = 0.003$) and was also associated with the number of polyps detected for the first colonoscopy ($\chi^2 = 18.196$, $P = 0.001$). The different working periods had no statistical effect on the missed rate of diagnosis ($\chi^2 = 1.998$, $P = 0.849$). However, there was an increasing trend in miss rates towards the end of work and delayed work periods, both in the morning and afternoon. The highest miss rate (60.0%) was observed during delayed work in the afternoon. Additionally, poor bowel preparation was significantly more common during delayed work in the afternoon.

Conclusions The increasing trend in miss rates towards the end of work and delayed work periods deserves clinical attention. Endoscopists cannot always stay in good condition under heavy workloads.

Keywords Colorectal polyps, Missed diagnosis, Working time, Artificial intelligence

Background

Colonoscopy screening and resection of colorectal polyps could significantly reduce the incidence of colorectal cancer [1]. Missed polyps, particularly adenomatous polyps, are associated with the development of post-colonoscopy colorectal cancers [2, 3]. The endoscopist, who performs

colonoscopy and identifies colorectal polyps, is one of the important factors influencing the rate of missed diagnosis of polyps [4, 5]. However, with a heavy endoscopic workload and extended working hours, the endoscopist's physical strength, concentration, and mental state may change toward the end of work or during delayed work, potentially affecting the detection or missed diagnosis of colorectal polyps. This study retrospectively analyzed the possible factors of missed diagnosis in patients with colorectal polyps in colonoscopy, and especially first analyzed the influence of the different working periods (work, near the end of work, and delayed work).

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Methods

Study population

This study was approved by the ethics committee of the First Affiliated Hospital of Nanjing Medical University (no. 2023-SR-196). The patients with colorectal polyps who underwent two colonoscopies in our endoscopy center between July and December 2022 were included. The first colonoscopy was performed in the outpatient department for the detection of polyps, and the second was performed in the inpatient department for the treatment of those polyps. All colonoscopies should reach the ileocecal region, and patients with inflammatory bowel disease or familial polyposis were excluded. All information was collected from the imaging system in the endoscopy center. A total of 482 patients were included, 308 males and 174 females, aged 26–88 years, with an average age of 57.76 ± 11.33 years.

Colonoscopy and bowel preparation

According to the registration and schedule of the endoscopy center, the colonoscopy and the corresponding endoscopist for outpatients were performed. Usually, there were 10 rooms per day for outpatient endoscopy in the morning and 2 or 3 rooms in the afternoon. Endoscopists were required to complete at least 30 points (one gastroscopy = 1 point, one colonoscopy = 2 points) of work per half-day shift. The performance assessment started in October 2022, and according to the workload of endoscopists, there would be an additional reward for each additional point after the workload exceeded 35 points every half-day shift. Most colonoscopies could be completed on time during working hours, while the number of colonoscopies near the end of work or delayed work was actually a minority. If the patient had a gastroscopy, it should be finished first. Bowel preparation drugs were generally polyethylene glycol or sodium phosphate. The same-day administration was used, and patients do not drink water for at least 2 h before colonoscopy. Defoamers, such as dimethicone or simethicone, were regularly used. The bowel preparation protocol for inpatients was the same as that for outpatients, and the endoscopist was arranged by the patient's department or ward.

Definition of evaluation criteria and related factors

Patients with missed diagnoses were defined as those who had newly discovered polyps during the second colonoscopy. The miss rate of patients = Number of patients with missed diagnosis / Total number of patients. The Boston bowel preparation scale was used to assess bowel preparation level, ≥ 6 was classified as general, and the opposite was poor. Endoscopists with more than 2 years of experience or more than 10,000 examinations were considered senior endoscopists, they often could perform endoscopic ultrasound and endoscopic

submucosal dissection. Conversely, the junior endoscopist had less than 2 years of experience or examinations less than 10,000, they often only performed gastrointestinal endoscopy or could complete endoscopic mucosal resection. The working periods were divided into work, near the end of work, and delayed work, respectively, in the morning and afternoon. According to the working hours and workload of the endoscopy center, they were specified as 8:00–10:30, 10:30–11:30, 11:30–14:00, 14:00–16:00, 16:00–17:30, and after 17:30, respectively.

Statistical analysis

Data were analyzed using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA). The measurement data were expressed as mean \pm standard deviation ($\bar{x} \pm s$) in accordance with the normal distribution, and the count data were expressed as the number or percentage (%). The chi-square test, or Fisher exact test, was used for statistical analysis. Univariate logistic regression was used to analyze the risk factors. Statistical significance was indicated by $P < 0.05$.

Results

Factors for the miss rate of patients

The miss rate of patients was 48.1% (232/482), and the patients with the number of missed polyps of 1, 2, and ≥ 3 accounted for 21.1%, 13.3%, and 13.7%, respectively. The missed sites were mainly in the transverse colon (25%) and ascending colon (23%), followed by the sigmoid colon (18%) and descending colon (15%). In the analysis of factors such as patient age, patient gender, different working periods, level of bowel preparation, anesthesia or not, number of detected polyps for the first colonoscopy, endoscopist's seniority, and different departments (Table 1), only the age of the patient was found to be related to the miss rate of diagnosis ($\chi^2 = 9.304$, $P = 0.010$). The miss rate of diagnosis was 22.6%, 48.1%, and 51.9% for the group of age < 40 years, the group of 40–60 years, and the group of ≥ 60 years, respectively. The risk of the miss rate of patients increased with patient age (OR = 1.025, 95% CI: 1.009–1.042, $P = 0.003$). Compared with the group of age < 40 years, the miss rate of patients was significantly higher in the group of 40–60 years and the group of ≥ 60 years (Fig. 1A), with OR values of 3.176 and 3.692, respectively. In addition, patient age was associated with the number of detected polyps during the first colonoscopy ($\chi^2 = 18.196$, $P = 0.001$). Three or more polyps (55.6%) were mainly detected in patients aged ≥ 60 years, and one polyp (45.2%) was often detected in patients aged < 40 years (Fig. 1B). The analysis of different weeks of colonoscopy, whether performance assessment was performed, whether the two colonoscopies were performed by the same endoscopist or in the same department, and the size of the largest polyp also did not

Table 1 Miss Rate of patients with colorectal polyps and risk factors

Factors	No missed diagnosis	Missed diagnosis	Chi-square value	P value
Colonoscopy time			0.030	0.862
Morning	186(52.1)	171(47.9)		
Afternoon	64(51.2)	61(48.8)		
Bowel preparation quality			0.514	0.473
General	183(52.9)	163(47.1)		
Poor	67(49.3)	69(50.7)		
Number of detected polyps			1.813	0.404
1 polyp	83(56.5)	64(43.5)		
2 polyps	54(50.5)	53(49.5)		
≥ 3 polyps	113(49.6)	115(50.4)		
Age of patient			9.304	0.010
<40 years	24(77.4)	7(22.6)		
40–60 years	122(51.9)	113(48.1)		
≥ 60 years	104(48.1)	112(51.9)		
Gender of patient			2.164	0.141
Female	98(56.3)	76(43.7)		
Male	152(49.4)	156(50.6)		
Different working periods			1.998	0.849
AM work	110(54.2)	93(45.8)		
AM near the end	43(51.8)	40(48.2)		
AM delayed work	33(46.5)	38(53.5)		
PM work	39(54.2)	33(45.8)		
PM near the end	23(47.9)	25(52.1)		
PM delayed work	2(40.0)	3(60.0)		
Anesthesia method			0.054	0.816
No sedation	18(50.0)	18(50.0)		
Sedation	232(52.0)	214(48.0)		
Seniority of endoscopists			0.530	0.767
Senior	72(53.7)	62(46.3)		
Junior	165(51.6)	155(48.4)		
trainee	13(46.4)	15(53.6)		
Department			1.071	0.585
Gastroenterology	157(53.8)	135(46.2)		
Digestive Endoscopy	50(49.0)	52(51.0)		
Geriatric and Pancreas Center	43(48.9)	45(51.1)		
Performance assessment			1.266	0.261
No	217(50.9)	209(49.1)		
Yes	33(58.9)	23(41.1)		

significantly affect the miss rate of patients. Multivariate logistic regression was also used, but only patient age was shown to be an independent influencing factor.

The effect of different working periods

The miss rate of patients in different working periods were shown in Fig. 1C. In the morning, although there was no significant statistical difference in the miss rate of patients in the period of work, near the end of work, and delayed work, it showed an increasing trend in values, which were 45.8%, 48.2%, and 53.5%, respectively. The miss rate of patients in the three periods in the afternoon also showed an increasing trend, which were 45.8%, 52.1%, and 60.0%, respectively. And the miss rate in the

delayed work period in the afternoon was the highest. The work was delayed until 13:18 in the morning and 18:01 in the afternoon. There was no statistically significant effect on the number of missed polyps by different working periods. The highest proportion of patients with 1 polyp missed (27.1%), 2 polyps missed (40.0%), and 3 or more polyps missed (21.1%) were found in near the end of work in the afternoon, delayed work in the afternoon, and delayed work in the morning, respectively. However, the different working periods had a significant effect on the level of bowel preparation (Fisher’s exact test value=11.978, $P=0.030$), and the poor bowel preparation was significantly more common during delayed work in the afternoon, reaching 100% (Fig. 1D). The total

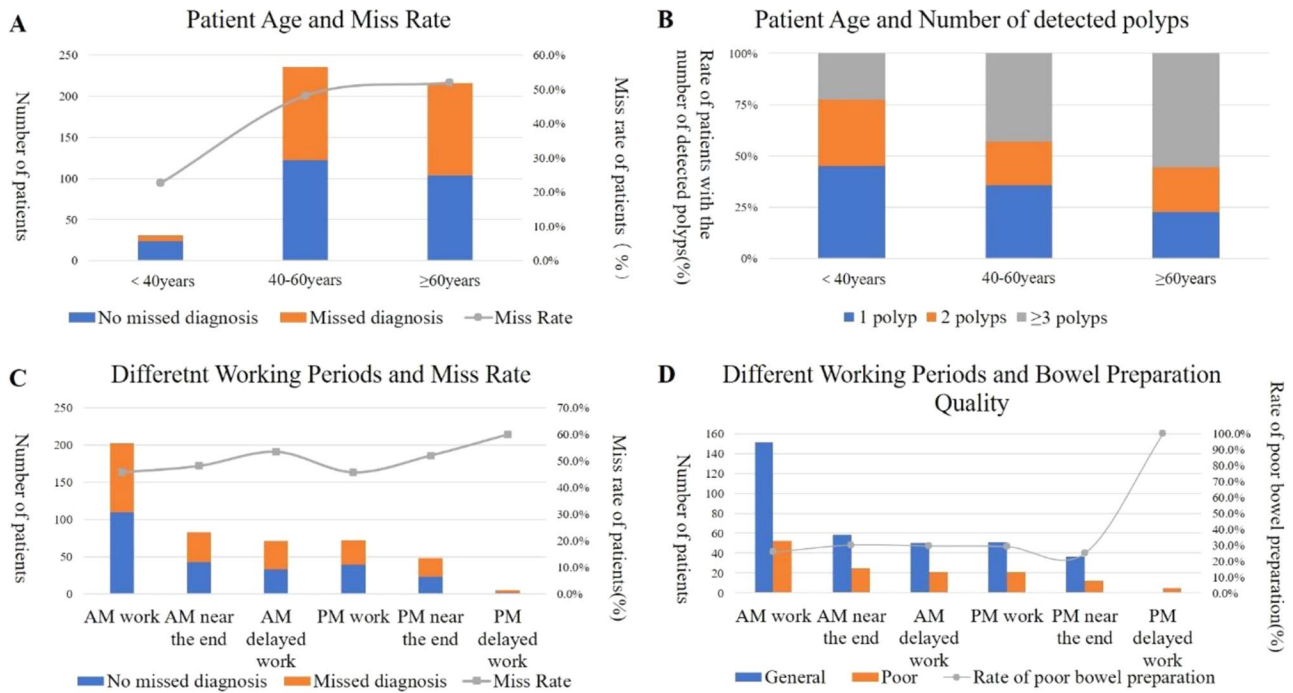


Fig. 1 Factors for the miss rate and effect of different working periods. **A** The miss rate in different patient age groups; **B** The number of detected polyps in different patient age groups; **C** The miss rate in different working periods; **D** Bowel preparation quality in different working periods

poor bowel preparation rate was 28.2%. The highest rates of poor bowel preparation in the morning and afternoon were near the end of work (30.1%) and delayed work (100.0%), respectively. There was also a significant difference in the seniority of endoscopists in the morning and afternoon ($\chi^2=78.152, P<0.001$). The senior endoscopists (77.6%) were mainly in the morning, while the proportion of junior endoscopists (52.8%) and trainees (12.8%) increased significantly in the afternoon.

Discussion

Colorectal polyp is the most common lesion in colonoscopy, and the adenomatous polyp is closely associated with colorectal cancer [6]. The adenoma detection rate increased by 1%, and the risk of interval colorectal cancer decreased by 3% [7]. However, the rate of missed adenomatous polyps during colonoscopy could reach 30 to 40% [8, 9]. It has been reported that the majority of newly discovered neoplastic polyps were missed in previous colonoscopy one year ago, and only 11% were true recurrence [10]. Therefore, it is important for the prevention of colorectal cancer by reducing the rate of missed patients with colorectal polyps and analyzing the associated risk factors. Additionally, this study first reported the effect of the different working periods (work, near the end of work, and delayed work) on the miss rate of patients with colorectal polyps.

The influence of different timings of colonoscopy on polyp detection rate is controversial [11, 12]. Some

studies found that the polyp detection rate decreased as the day progressed, and it may be related to the fatigue and shift schedule of the endoscopists [13–15]. Conversely, the detection of colon polyps during colonoscopy was stable throughout the workday was reported [16–18]. However, there is a lack of research on the effect of working periods on the miss rate of patients with colorectal polyps. Our study found no significant difference in the miss rate of patients with colorectal polyps during the periods of work, near the end of work, or delayed work. Notably, there was an increasing trend in the value of the miss rate towards the end of work and delayed work periods, both in the morning and afternoon. And the miss rate was highest in the afternoon. This reminded endoscopists to pay more attention during this period and managers to reasonably arrange the endoscopy workload and optimize the staff schedule. As the delayed time increases, the miss rate may show a statistically significant difference.

In previous studies [12–16], working time mainly represented the fatigue of endoscopists and usually divided into hours or morning and afternoon, while this study classified the time as work, near the end of work, and delayed work, according to the working hours and workload. As the work progresses, endoscopists may experience fatigue such as physical exertion, distraction, lack of energy, and physical discomfort. And they may also experience mentality changes such as been anxious to get off work and worrying about workload and performance

indicators when facing near the end of work and delayed work. These may affect the detection rate and miss rate of colorectal polyps. Questionnaire surveys on fatigue and mentality changes among endoscopists of different ages, seniorities and genders, are worthy of further clinical study.

More and more strategies and techniques are used for colonoscopy to reduce missed diagnoses or improve detection rate [19, 20], such as retroflexion in the right colon, ≥ 6 -minute withdrawal, use of transparent caps, high-definition endoscopy, wide-angle endoscopy, nurse-assisted observation, etc. However, endoscopists are the main implementers who operate colonoscopy and make the diagnosis, and they are also one of the important factors affecting the miss rate of patients with colorectal polyps. Endoscopists may experience fatigue, distraction, decreased alertness, and visual perception and identification errors, resulting in a missed diagnosis during the colonoscopy. Artificial intelligence is becoming an important tool to reduce these human influences [9, 21, 22]. The recognition system based on deep learning architecture can not only accurately identify polyps, but also reduce the missed diagnosis rate of adenomas, including visual missed diagnosis and exposure missed diagnosis [23].

Previous studies [24, 25] showed that the number of detected polyps, the experience of endoscopists, the level of bowel preparation, and other factors were related to the miss rate of polyp patients. However, these factors in this study only showed the same numerical trends as in previous studies. In addition, the miss rate of polyps (especially for adenoma) and related factors such as the morphology and pathology were not analyzed in this study. The miss rate in our study was very high, which may be related to the large workload and teaching work of endoscopy in our center. The result was unacceptable in clinical practice, but this is precisely clinical question that our study hopes to present. We need to confront these issues head-on, including workload appointments, individual performance reviews, and the teaching work. Besides, some endoscopists wore goggles or face shields for endoscopic operations during the epidemic of novel coronavirus in this study, which may also be a possible factor for the high miss rate. The sample size of this study was limited and may be underestimated, and the case source was also single. As a retrospective study, multiple confounding factors may have influenced the results, and this study lacked techniques such as cap-assisted colonoscopy, narrow band imaging, or chromoendoscopy, which could affect our results. Also, there is a selection bias because included were only those patients that had at least one polyp detected during the first colonoscopy, and the endoscopist may not remain vigilant after finding large or more polyps during colonoscopy screening

because such patients may be recommended for hospitalization. Large, multi-center prospective randomized controlled studies could provide more reliable results.

Conclusion

In conclusion, the miss rate of patients with colorectal polyps had no significant change during different working periods, but the increasing trend towards the end of work and delayed work periods deserves clinical attention. Endoscopists cannot always stay in good condition under heavy workloads. Artificial intelligence may be an important tool to reduce the rate of missed diagnoses and avoid human factors.

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Author contributions

Zhi He conducted research design, drafting articles and data analysis. Qing Xu collected data, analyzed data and made charts. All authors have read and approved the final manuscript.

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Data availability

All data generated or analyzed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate

This study protocol was reviewed and approved by the ethics committee of the First Affiliated Hospital of Nanjing Medical University (the approval number: no. 2023-SR-196). Informed consent for colonoscopy and treatment was obtained from each patient before the associated procedure. For this, research was retrospective and the data were anonymous, the study had been granted an exemption from requiring written informed consent by the ethics committee of the First Affiliated Hospital of Nanjing Medical University (the approval number: no. 2023-SR-196).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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