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Original Article

Comparison of application value between conventional air insufflation and water infusion in colonoscopy

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Abstract: Objective: To discuss the feasibility of water infusion colonoscopy and its difference with traditional air insufflation colonoscopy in application value. Methods: A prospective randomized controlled clinical study was designed to include 200 patients who underwent sedation-free diagnostic colonoscopy. Among them, 100 patients were treated with water infusion colonoscopy (observation group) and 100 patients were treated with air insufflation colonoscopy (control group). All operations were performed independently by the same experienced physician. The differences in colonoscopy related values, colon adenoma detection rate, and follow-up findings between the patients of two groups were compared. Results: There was no significant difference in the Boston bowel preparation scale (BBPS) score of the left hemicolon, transverse colon, right hemicolon, total BBPS scores, and bubble amount between the two groups (P>0.05). In the observation group, the scope-forward time, the time to reach the ileocecal junction, and the total operation time were significantly longer than that of the control group (P<0.01). The proportion of patients in whom the ileocecal junction was successfully reached was significantly higher in the observation group. The intraoperative abdominal pain visual analog scale (VAS) score, abdominal distension VAS score, the proportion of postural change, and the proportion of abdominal compression were all significantly lower in the observation group (P<0.05). There were no significant differences in the endoscope hardness adjustment rate, the scope withdrawal time, total detection rate of adenomas, and the size or location of colon adenomatous lesions between the two groups (P>0.05). Compared with control group, the incidence of abdominal pain and VAS scores were significantly lower in the observation group (P<0.05), and the willingness of patients to perform colonoscopy again was significantly higher (P<0.01). Conclusion: Patients' tolerance and examination satisfaction are significantly better when using water infusion colonoscopy compared with traditional air insufflation colonoscopy, but the operation times are longer.

Keywords: Water infusion colonoscopy, air insufflation colonoscopy, colon adenoma, abdominal pain, application value

Introduction

Based on the carcinogenesis model of "Adenoma-atypical hyperplasia-cancer", most colorectal cancers originate from the canceration of benign adenomatous polyps [1, 2]. It usually takes 5-15 years for a colonic adenoma to become cancerous [3], thus early detection and resection can effectively prevent the canceration progress [4]. Therefore, cancer screening is considered an effective method to prevent colorectal cancer. Colonoscopy, as the "gold standard" for screening early colorectal cancer, is widely used in the diagnosis and treatment of intestinal diseases [5].

In colonoscopy, filling the intestinal cavity is crucial to completion of the exploration [6, 7]. In traditional colonoscopy, the method is to use an air pump to fill the cavity. In recent years, there have been studies [8-10] covering the shortcomings of air insufflation colonoscopy, which mainly include: 1. Although air can effectively fill the intestinal cavity, the pressure is difficult to control precisely, which may cause the stretching of the intestinal canal. 2. When the intestinal cavity is stretched, it is conducive to the formation of loops, which is unsuitable for the insertion. 3. Intensive discomfort feeling of abdominal pain and bloating will cause poor tolerance of colonoscopy and a patient may even

reject examination, which prevents performing colonoscopy. Therefore, it is necessary to improve the tolerance and satisfaction of colonoscopy. At present, both painless enteroscopy and changing of the intestinal filling medium are two main directions of research. However, painless enteroscopy with intravenous anesthesia is expensive. It also has many contraindications as well as various postoperative adverse reactions [11, 12]. Using CO_2 instead of air to fill the intestinal cavity still raises the problem of gas-induced intestinal stretching [13].

Using water instead of air has received attention in recent years [14-16]. Filling the intestinal cavity with water was first proposed in the 1980s [14]. Subsequent studies confirmed the feasibility of water infusion colonoscopy and suggested that warm water at 37°C is more beneficial to reduce the adverse reactions of the examination than room temperature water [15, 16]. Leung et al. have made some important contributions to the development of water infusion colonoscopy [17, 18]. For the first time, they made it clear that water infusion colonoscopy can be an independent scope-forward technique. However, there are still some shortcomings of water infusion colonoscopy at present: 1. Compared with air insufflation colonoscopy, the efficacy of water infusion colonoscopy still needs to be clarified with more clinical research. 2. The procedure of water infusion colonoscopy lacks standardization and thus, is less popular. At present in China, the application of water infusion colonoscopy is mainly localized in Tier 3 hospitals, and is less popular among basic hospitals.

Based on this, a prospective single-center randomized controlled study was adopted in this study to clarify the clinical effect of water infusion colonoscopy as well as to summarize relevant experiences and skills.

Materials and methods

General information

A prospective randomized single-center study was designed, and 200 patients undergoing colonoscopy in Yuyao People's Hospital between April 2019 and March 2020 were prospectively selected. The inclusion criteria [19] were as follows: patients had symptoms such as hemafecia and changes in bowel habits, and were suspicious for colon adenoma or carcinoma; patients were scheduled to undergo sedation-free colonoscopy; patients were 18-80 years old; patients were informed about the content of this study, voluntarily participated, and signed an informed consent. The exclusion criteria were as follows: patient had undergone colonoscopy and treatment in the past; patient had severe ascites, intestinal obstruction, or other contraindications for colonoscopy; patient had other diseases that could impact the assessment of pain; patient had mental illness or other situations so could not cooperate with the study.

This study was approved by the Medical Ethics Committee of Yuyao People's Hospital.

Methods

After admission, the contents of the study as well as the process of colonoscopy, the discomfort that may be faced during the examination and the countermeasures were explained by professional medical personnel to the patient. The visual assessment method (VAS) was emphasized to patients and tests were conducted to determine the reliability and authenticity of the VAS results. After the health education was completed, an appointment for the patient's colonoscopy was made. On the night before the inspection, a total of 750 mL liquor composed of warm water and 45 mL sodium phosphate solution (Chengdu Dikang Pharmaceutical Co., Ltd., H20103036) was orally administrated, which was repeated again on the day of examination. One hour before the inspection, 15 mL of simethicone emulsion (Jiangsu Hanchen Pharmaceutical Co., Ltd., H20173062) was orally taken.

All surgical operations were completed independently by the same experienced doctor who has mastered the techniques of water infusion and air insufflation colonoscopy. The electronic duodenal endoscope (CF-HQ290i, OLYMPUS) was used. After confirming the patient's examination method, the patient was assisted to lie on the left and flex the knee to expose the anus. For air insufflation colonoscopy, air was injected into the intestinal cavity, and the one-man colonoscopy method (Kudo Shin'ei method) was used to assess the intestinal condition. The hardness of the colonoscope was adjusted

reasonably. If the patient had significant abdominal discomfort, the manual abdominal compression was adopted; if there was difficulty in scope entering, the patient was assisted to change their position. For water infusion colonoscopy, the air pump of the colonoscope was turned off, and residual gas in the intestinal cavity was sucked out, thereby reducing air bubbles. The intestinal cavity was repeatedly washed with constant 37°C water and the sewage was sucked out until the colon was clean. Then the colon was filled with water, and the filling of the intestinal cavity was continuously monitored. In the process of forwarding the mirror, the direction of the intestinal canal was carefully monitored. The stiffness of the colonoscope and position of the patient was adjusted similarly with air insufflation colonoscopy. When the scope reached the ileocecal junction, the scope-forward process was terminated and the physician began to withdraw the scope. If the ileocecal junction cannot be reached, double-balloon endoscopy was performed to check the condition of the ileocecal junction. Air insufflation technique was used in all patients to withdraw the scope, and extra air bubbles and sewage were sucked out to make the intestinal mucosa look clear. The withdrawal process was no less than 6 minutes.

Outcome measures

The main observation indicators include the patient's tolerance, the detection rate of colon adenoma, and the patient's condition after colonoscopy. The secondary observation indicators include intestinal preparation and intestinal bubble volume, colonoscopy time.

Intestinal preparation and intestinal bubble volume: Boston bowel preparation scale (BBPS) was used [20]. It divides the colon into three segments, namely the left hemicolon (including the descending colon, sigmoid colon, and rectum), transverse colon (including hepatic flexure and splenic flexure of the colon) and right hemicolon (including the cecum and ascending colon). The cleanliness of each segment of the colon is divided into 4 levels, ranging from poor (0 points) to good (3 points). The total intestinal cleanliness score is the summation of each segment score. According to the clarity of the visual field, it is divided into 4 levels. level I: Basically no bubbles, clear vision; level II: the amount of bubbles <1/3 of the visual field, which does not affect the observation of the mucosa; level III: the amount of bubbles occupies 1/3-2/3 of the visual field, which affects the observation of the mucosa; level IV: the amount of bubbles occupies >2/3 of the visual field, which has a significant influence on the observation of the mucosa [21].

Colonoscopy examination time: The time to advance forward the scope, time from entering the scope to the ileocecal junction, time to withdraw the scope, total examination time, and the rate of successfully reaching the ileocecal junction was used to evaluate the examination time. The rate of successfully reaching the ileocecal junction (%) = (number of patients underwent water infusion or air insufflation colonoscopy in whom the doctor successfully reached the ileocecal junction/total number of patients in the group) × 100.

Patients' tolerance: The intraoperative abdominal pain visual analogue scale (VAS) score, abdominal distension VAS score, endoscopic hardness adjustment rate, postural changing rate, and abdominal compression rate were used to evaluate the patient's examination tolerance. Abdominal pain and distension VAS scores were evaluated after the scope-forward procedure was completed. During the examination, the adjustment of endoscope hardness, postural changes, and the number of abdominal compressions were recorded, and the incidence of each index was calculated after the examination. Endoscopic hardness adjustment rate (%) = (number of patients who needed and adjustment of the endoscope hardness during the water infusion or air insufflation colonoscopy/total number of patients in the same group) × 100; Postural change rate (%) = (Number of patients in need of postural adjustment during the water infusion or air insufflation colonoscopy/total number of patients in the same group) × 100; Abdominal compression rate (%) = (number of patients requiring abdominal compression during the water infusion or air insufflation colonoscopy/total number of patients in the same group) × 100.

The detection rate of colon adenoma: The total detection rate of adenomas in two groups of patients was calculated, and the number of detected adenoma lesions was recorded. The differences in the size of adenoma lesions (<5

Table 1. Comparison of baseline data between the two groups

Item	Observation group (n = 100)	Control group (n = 100)	χ^2/t	P
Age	50.5±12.9	51.3±14.5	0.412	0.681
Gender (M/F, n)	63/37	59/41	0.336	0.562
BMI (kg/m^2)	24.52±2.91	24.24±3.17	0.651	0.516
History of abdominal surgery (n)	9	11	0.222	0.637
Indications for colonoscopy (n)			0.323	0.459
Abdominal pain	30	32		
Hemafecia	20	16		
Constipation	17	20		
Physical check-up	8	11		
Others	25	21		
Amount of water consumed 1h before inspection (L)	2.2±0.5	2.1±0.6	1.280	0.202
Number of urinations 1 h before examination (times)	6.5±2.5	6.1±2.9	1.045	0.298

Note: BMI: body mass index.

mm, 5-10 mm, >10 mm) and the differences in adenoma lesions detected at different locations (left hemicolon, transverse colon, right hemicolon) were analyzed in the two groups. Adenoma detection rate (%) = (number of patients with colon adenoma detected during the water infusion or air insufflation colonoscopy/total number of patients in the same group) × 100.

The patient's condition after colonoscopy was based on: the incidence of abdominal pain, the VAS score of abdominal pain, the duration of abdominal pain, and the patient's willingness to undergo colonoscopy again. Incidence of abdominal pain (%) = (number of patients with abdominal pain during the water infusion or air insufflation colonoscopy/total number of patients in the same group) × 100.

Statistical analysis

SPSS 24.0 (SPSS Inc. Chicago, IL, USA) was used for statistical analysis of the data: the enumeration data was expressed as number (percentage) (n (%)), data with a theoretical number T≥5 and a total sample size n≥40 were tested with Pearson χ^2 test; data with a theoretical number 1≤T<5 and n≥40 were tested using the continuity-corrected χ^2 test; data with a theoretical number T<1 or n<40 were tested using Fisher's test. The Mann-Whitney U test was used to compare the ranked data between groups. The measurement data was expressed as mean ± standard deviation ($\bar{X}$ ± sd), and the independent sample t-test was used for comparison between groups. The test level was selected with bilateral α = 0.05, and P<0.05 was considered significant.

Results

Baseline information

The study included 200 patients with no fell off. There was no significant difference in baseline data between the two groups (P>0.05) (**Table 1**).

There was no significant difference in intestinal preparation and intestinal bubble volume between the two groups of patients

There was no significant difference in the BBPS scores of the left hemicolon (**Figure 1A**), transverse colon (**Figure 1B**), right hemicolon (**Figure 1C**) and total intestinal BBPS (**Figure 1D**) between the two groups (P>0.05). According to the clarity of the visual field, the intestinal air bubble volume was graded as I, II, III and IV. There was no significant difference in intestinal air bubble volume between the two groups of patients (P>0.05) (**Table 2**).

The observation group had a higher rate of reaching the ileocecal junction

As shown in **Table 3**, the scope-forward time, the time for reaching the ileocecal junction, and the total time of the observation group were significantly longer than those of the control group (P<0.01), and there was no significant difference in the scope-exit time between the

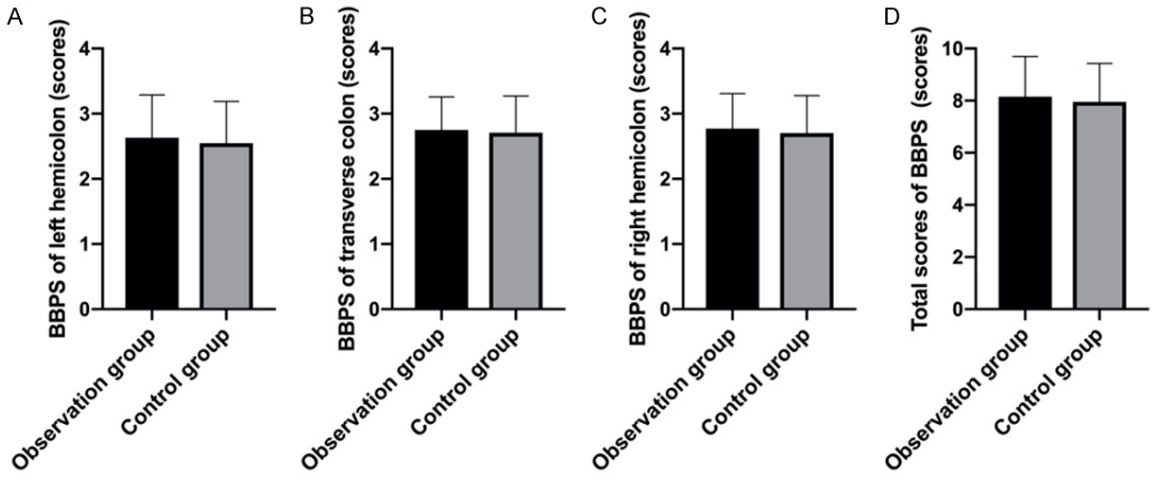

Figure 1. BBPS scores of the patients of two groups. A. BBPS scores of the left hemicolon; B. BBPS scores of the transverse colon; C. BBPS scores of the right hemicolon; D. Total intestinal BBPS scores. BBPS: Boston bowel preparation scale.

Table 2. Classification of intestinal bubble volume between the two groups

Intestinal bubble volume	Observation group (n = 100)	Control group (n = 100)	U	P
Grade I	55	49	0.336	0.427
Grade II	36	38		
Grade III	7	10		
Grade IV	2	3		

two groups (P>0.05). The rate of successfully reaching the ileocecal junction in the observation group was significantly higher than that in the control group (100% vs 94%, P = 0.038).

Patients in the observation group have better tolerance in colonoscopy examination

The intraoperative abdominal pain VAS score, abdominal distension VAS score, postural change rate, and abdominal compression rate of the observation group were significantly lower than those of the control group (P<0.05), and there was no significant difference between the endoscope hardness adjustment rates between the two groups (P>0.05) (**Table 4**).

The detection rate of colon adenoma in water infusion colonoscopy is similar to that of traditional air insufflation colonoscopy

In the observation group, 29 patients were diagnosed with colon adenoma and a total of 35 adenomatous lesions were detected. In the control group, 27 patients were diagnosed with colon adenoma and a total of 37 adenomatous lesions were detected. There was no significant difference in total detection rate of adenoma between the two groups (29.00% vs 27.00%, P = 0.753). As shown in **Table 5**, there was no significant difference in the size and location of colon adenoma lesions detected in the two groups of patients (P>0.05).

Patients with water infusion colonoscopy have a higher willingness to be examined again than patients with traditional air-insufflation colonoscopy

As shown in **Table 6**, the incidence of abdominal pain and VAS scores of patients in the observation group after examination were significantly lower than those of the control group (P<0.05), and the willingness to undergo colonoscopy again was significantly higher than that of the control group (P = 0.001).

Discussion

This study showed that water infusion colonoscopy had a higher rate of reaching the ileocecal junction than air insufflation colonoscopy. Patients with water infusion colonoscopy also had a significant advantage of greater intraop-

Table 3. Colonoscopy time of two groups of patients

Item	Observation group (n = 100)	Control group (n = 100)	χ^2/t	P
Scope-forward time (min)	9.24±1.35	7.65±1.02	9.397	<0.001
Time of reaching ileocecal junction (min)	7.85±2.79	5.32±2.32	6.972	<0.001
Scope-exit time (min)	5.95±1.35	5.62±1.07	1.916	0.057
Total time (min)	15.19±1.83	13.27±1.52	8.071	<0.001
Rate of successfully reaching ileocecal junction (%)	100.00%	94.00%	4.296	0.038

Table 4. Intraoperative tolerance of the two groups

Item	Observation group (n = 100)	Control group (n = 100)	χ^2/t	P
Intraoperative abdominal pain VAS score (points)	2.31±1.50	4.57±1.72	9.903	<0.001
Intraoperative abdominal distension VAS score (points)	2.59±1.68	4.92±2.02	8.868	<0.001
Postural change rate (%)	28.00	43.00	4.913	0.027
Abdominal compression rate (%)	12.00	33.00	12.645	<0.001
Endoscope hardness adjustment rate (%)	9.00	7.00	0.272	0.602

Note: VAS: visual analogue scale.

Table 5. The size and location of colon adenomatous lesions in two groups of patients

Item	Observation group (n = 100)	Control group (n = 100)	χ^2	P
Adenomatous lesion size (n)			0.233	0.641
<5 mm	25	23		
5-10 mm	9	13		
>10 mm	1	1		
Location of Adenomatous lesions (n)			0.406	0.58585
Left hemicolon	22	21		
Transverse colon	8	10		
Right hemicolon	5	6		

Table 6. Postoperative abdominal conditions and willingness to undergo colonoscopy again in the two groups

Item	Observation group (n = 100)	Control group (n = 100)	χ^2/t	P
Abdominal pain after examination				
Incidence (%)	30.00	45.00	4.800	0.028
VAS score (points)	0.75±0.33	1.21±0.55	7.172	<0.001
Duration (h)	0.39±0.28	0.45±0.34	1.362	0.175
Willingness to undergo colonoscopy again (n)			10.526	0.001
Yes	90	72		
No	10	28		

erative tolerance. Before the operation, the intestinal preparation of the two groups of patients was evaluated. There was no significant difference in the total BBPS scores and BBPS scores of the left hemicolon, the transverse colon, and the right hemicolon of the two groups, and there was no significant difference in the amount of bubbles in the visual field. The study by Wang et al. showed that water infusion colonoscopy and traditional air insufflation

colonoscopy can obtain an equivalent clarity of vision field, and the results were consistent with this study [22]. During the examination, this study compared the examination time of the two groups of patients. The results showed that the water infusion colonoscopy had its disadvantages of significantly longer scope-forwarding time, time to reach the ileocecal junction, as well as the whole procedure time. The meta-analysis of Liu et al. showed that the time of forwarding the scope and the caecum intubation time of the water infusion group was significantly longer than those of the air insufflation group, which was consistent with the results of this study [23].

The intraoperative and postoperative tolerance and the detection rate of adenoma were the main observation indicators of this study. The intraoperative abdominal pain VAS score and abdominal distension VAS score of the observation group were significantly lower than those of the control group. The reason may be [24-26]: 1. As a filling medium, warm water has the effect of relieving intestinal spasm; 2. Due to gravity, water can follow the direction of the intestine after taking the left lying position, thus reducing the stretching of both the mesentery and intestinal canal; 3. The water flow opens the channel to the sigmoid colon, allowing the colonoscope to pass through without forming intestinal loops, reducing the distortion of the sigmoid colon. The postural change rate and abdominal compression rate of the observation group in the study were significantly lower than those of the control group, which also indicated that the intraoperative tolerance in water infusion colonoscopy was better. This was consistent with the research conclusions of Leung et al. [27]. The detection rate of colon adenoma in patients examined by two techniques was also compared. The results suggested that there was no significant difference in the detection rate of total adenomas between the two groups of patients, and there was also no significant difference in the size and location of the detected colon adenoma. Jia et al. concluded that, compared with traditional air insufflation colonoscopy, water infusion colonoscopy could improve the detection rate of colon adenoma [28]. A randomized controlled study by Anderson et al. also showed that water-assisted colonoscopy could improve the detection rate of colon adenomas [9]. The main reason for the inconsistency between the results of this study and the above is that this study is a single-center randomized controlled study, thus the sample size was small, and the incidence of colon adenoma in the two groups may not be different by itself. In the postoperative observation, we found that the incidence of abdominal pain and VAS scores of the observation group after examination were significantly lower than that of the control group, but the pain duration was identical in both groups. After the water infusion colonoscopy, the number of patients who expressed their willingness to be examined again was significantly higher than that of the patients underwent traditional air insufflation colonoscopy, suggesting that the acceptance of water infusion colonoscopy was higher, which be because the patients had significantly reduced pain in examination [29].

In this study, both the water infusion and air insufflation colonoscopy were performed by the same physician. Combined with reports of previous studies, we summarized the experience and techniques of the water infusion colonoscopy technique [30-32] as follows: Before filling the intestine with water, repeatedly wash the rectum with warm water, then suck out sewage and residual gas to get a clearer vision; The air pump does not need to be turned off during the whole scope-forwarding process; When the intestinal wall folds affect the judgment of the intestinal canal direction, a short air insufflation can be performed. After the path of the intestinal canal is clearly identified, we turn off the air pump and continue the water injection.

The design of this study also has certain flaws: our study was a single-center prospective randomized controlled study with a small sample size that may cause some bias. There was no significant difference in the incidence of colon adenoma in the observation group and the control group, thus, it was not suitable to evaluate the efficacy in detecting colon adenomas. The application of carbon dioxide in gas insufflation colonoscopy has been verified, while this study failed to set up three experimental groups to clarify the efficacy of water infusion and carbon dioxide insufflation colonoscopy.

In summary, this randomized controlled study was designed to compare water infusion colonoscopy with traditional air insufflation colonoscopy. Although water infusion colonoscopy

showed a disadvantage in terms of examination time, and the detection rate of intestinal adenoma was equivalent, patients underwent the water infusion colonoscopy had a significantly improved intraoperative tolerance, the pain of the patient's examination was significantly reduced, and the willingness to be examined again was significantly increased. This technique is beneficial for the promotion of one-man colonoscopy in the community-based medical system.

Disclosure of conflict of interest

None.

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