ORIGINAL ARTICLE

Safety and importance of colonoscopy in nonagenarians

Kuan-I Sung[a,b,e], Yen-Po Wang[a,b,d,e,*], Tien-En Chang[b,e], Huann-Sheng Wang[a,c,e], Jeng-Kai Jiang[c,e], Jiing-Chyuan Luo[a,b,e,f], Fa-Yauh Lee[b,e], Ming-Chih Hou[a,b,e], Ching-Liang Lu[a,b,d,e]

[a]Endoscopy Center for Diagnosis and Treatment,Taipei Veterans General Hospital, Taipei, Taiwan, ROC; [b]Division of Gastroenterology and Hepatology, Department of Medicine, Taipei Veterans General Hospital, Taipei, Taiwan, ROC; [c]Division of Colon and Rectum Surgery, Department of Surgery, Taipei Veterans General Hospital, Taipei, Taiwan, ROC; [d]Institute of Brain Science, National Yang Ming Chiao Tung University, Taipei, Taiwan, ROC; [e]School of Medicine, National Yang Ming Chiao Tung University, Taipei, Taiwan, ROC; [f]Keelung Hospital, Ministry of Health and Welfare, Keelung, Taiwan, ROC

Abstract

Background: With the growth of the aging population, the need for colonoscopies in nonagenarians is rising. However, few data on colonoscopies in extremely elderly individuals are available. To better acknowledge the role of colonoscopies in this specific group of patients, we conducted this study to evaluate the safety and clinical impact of colonoscopy in nonagenarian patients.

Methods: We performed a retrospective cohort study comparing nonagenarians who received colonoscopy in a tertiary medical center in Taiwan in 2016 with 76- to 80-year-old patients (relatively elderly patients) who were 1:1 propensity score matched by sex as the control subjects. The postcolonoscopy 30-day adverse events, mortality, and long-term survival were recorded.

Results: A total of 137 nonagenarians and 137 relatively elderly patients were included. The nonagenarians receiving colonoscopy were more likely to be hospitalized (40.1% vs 19.7%, $p < 0.001$), and the adjusted colonoscopy completion rates were comparable in both groups (92.0% vs 97.1%, $p = 0.063$). The overall adverse event rate and postcolonoscopy 30-day mortality rates were low in both groups (2.9% vs 1.5%, $p = 0.409$ and 2.2% vs 1.5%, $p = 0.652$, respectively). A total of 18.2% of the nonagenarians were diagnosed with advanced neoplasia. Among the nonagenarians diagnosed with colorectal cancer, the patients receiving surgery had a significantly lower risk of death than the patients receiving conservative management (hazards ratio 0.1044, 0.01275–0.8529, $p = 0.0352$).

Conclusion: Colonoscopy in patients older than 90 years is generally safe. Colonoscopy findings that led to surgery in nonagenarians diagnosed with colorectal cancer were associated with survival benefits.

Keywords: Colonoscopy; Colonic neoplasms; Nonagenarians

1. INTRODUCTION

Colorectal cancer (CRC) is the second most common cancer diagnosed in women and the third most common in men worldwide.[1] The incidence of CRC worldwide is predicted to increase to 2.5 million new cases by 2035.[2,3] Colonoscopy is one of the most recommended methods for CRC screening and colorectal disease treatment.[4] Colonoscopy allows for polypectomy, endoscopic mucosal resection, or endoscopic submucosal resection to prevent CRC.[5,6] CRC surveillance is suggested from 50 to 75 years of age and in patients who have >10 years of life expectancy in the United States.[7] The British Gastroenterological Society (BSG) guidelines also recommend screening and monitoring colonoscopy before 75 years of age based on comorbidities and relative CRC risk.[8] CRC screening is an important issue in an aging population, and the incidence of adenomatous polyps[9] and CRC increases with age.[10–12] Due to advances in medicine and increased life expectancy, the age of populations has increased quickly.[13] The population in Taiwan over 90 years old increased >4-fold in the last 10 years from 61 586 in 2009 to 281 062 in 2019.[14] The need for colonoscopy in these extremely elderly people also increased quickly. In current practice, patients over 90 years old often do not receive proper colonoscopy and treatment due to the doctor's or patient's unwillingness to consider the possibility of poor bowel clearance,[15] the high risk of anesthesia,[16] difficulty in cooperating with examinations, and the increased risk of complications during bowel preparation[17] and after colonoscopy.[18] Noninvasive computed tomography colography[19] and colon capsule endoscopy[20] are alternative methods for colon polyp detection. However, patients still need to take a large amount of laxatives for examination and may need repeated laxative usage for further endoscopic lesion resection. Additionally, these examinations are not routinely performed in Taiwan since they are not yet covered by health insurance due to the prohibitive costs. Therefore, colonoscopy remains

*Address Correspondence. Dr. Yen-Po Wang, Endoscopy Center for Diagnosis and Treatment, Taipei Veterans General Hospital, 201, Section 2, Shi-Pai Road, Taipei 112, Taiwan, ROC. E-mail address: ulnafu@gmail.com; ypwang@vghtpe.gov.tw (Y.-P. Wang).

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the most efficient and accurate method for the diagnosis and treatment of colorectal lesions.

People over the age of 90 years also have the highest risk of CRC among the elderly population.[11] Recently, a few small hospital cohort studies have shown that colonoscopy is practicable in elderly patients, even in patients over 90 years old, and more advanced neoplasms have been found in these elderly patients than in younger people.[15,21] However, most studies are from Western countries, and only limited data are reported for patients in Eastern countries, where aging has increased most sharply.[22] The diagnosis and treatment benefits from colonoscopy compared to the risks from adverse events in patients receiving colonoscopy over the age of 90 years are not known. We performed a retrospective study to evaluate the clinical outcomes and adverse events between patients receiving colonoscopy over the age of 90 years (termed nonagenarians) and patients aged 76 to 80 years (termed relatively elderly patients) and to improve our understanding of the impact of colonoscopy in nonagenarians.

2. METHODS

2.1. Enrolled subjects and colonoscopy data acquisition

We performed a hospital-based cohort study comparing colonoscopy outcomes between patients aged over 90 and aged 76 to 80 using the endoscopy databank in the Endoscopy Center for Diagnosis and Treatment of general tertiary medical center in Taiwan. All the patients aged over 90 years who received colonoscopies between January 2016 and December 2016 were enrolled as the nonagenarian group. The patients aged 76–80 years who received colonoscopy in the same period were propensity score matched by sex in a 1:1 ratio as a relatively elderly patient group (Fig. 1). The enrolled patients' endoscopy images, endoscopy reports, anesthesia records, and immediate adverse events were obtained from the endoscopy databank. Experienced endoscopists with a Taiwanese board of digestive endoscopy or colorectal surgery and fellows in training under an attending physician's supervision performed all the colonoscopies. The procedures were performed using Olympus CF-260 and CF-290 series colonoscopes (Olympus Medical Systems Co, Tokyo, Japan). Before colonoscopy, the patients received bowel preparation with polyethylene glycol, sodium phosphate, bisacodyl, or enema according to the physician's clinical decision. After colonoscopy, all the outpatients had outpatient clinic follow-up within 2 weeks for presentation of the colonoscopy results and further management. The inpatients continued their treatment in an ordinary ward.

The quality of the bowel preparation was graded as excellent, good, fair, or poor according to the Aronchick bowel preparation scale.[23] Excellent, good, or fair grades were considered adequate preparation in the present study. Complete colonoscopy was defined as intubation of the terminal ilium or postsurgical ileocolonic anastomosis with photographic documentation. Since some doctors did not complete the colonoscopy due to the discovery of a lesion or a tumor obstructing the lumen during the procedure, an adjusted completion rate was defined as the rate of colonoscopy reaching the cecum or terminal ileum stopped by an obstructing lesion or a target lesion found in all colonoscopies. Some of the patients received additional intravenous sedation, namely, midazolam, propofol, and alfentanil, administered by an anesthesiologist. The indication for colonoscopy, medication used for bowel preparation, colonoscopy completion, bowel preparation quality, colonoscopy findings, immediate adverse events, and technical difficulty were obtained from the endoscopy database.

2.2. Clinical data acquisition

The electronic medical records of the enrolled patients' clinical notes, emergency room notes, procedure notes, hospital admission notes, anesthesia records, surgery records, progress notes, and discharge summaries from 1 month before colonoscopy to 3 years after colonoscopy were retrieved manually from the electronic medical record system of the medical center. Two leading authors reviewed these patients' data manually. Patient demographics, American Society of Anesthesiologists (ASA) physical status classification,[24] major comorbidities, Charlson comorbidity index score,[25] adverse events up to 30 days after colonoscopy, clinical diagnoses of colonoscopy findings, and clinical staging of colorectal cancer according to the American Joint Committee on Cancer (AJCC) 8th edition classification were obtained. For patients who received nonsedation colonoscopy, two leading authors used the patients' clinical records to analyze their ASA physical status classification.

2.3. Definition of adverse events and clinical diagnosis

Adverse events included immediate and long-term adverse events, including all medical events that occurred within a 30-day

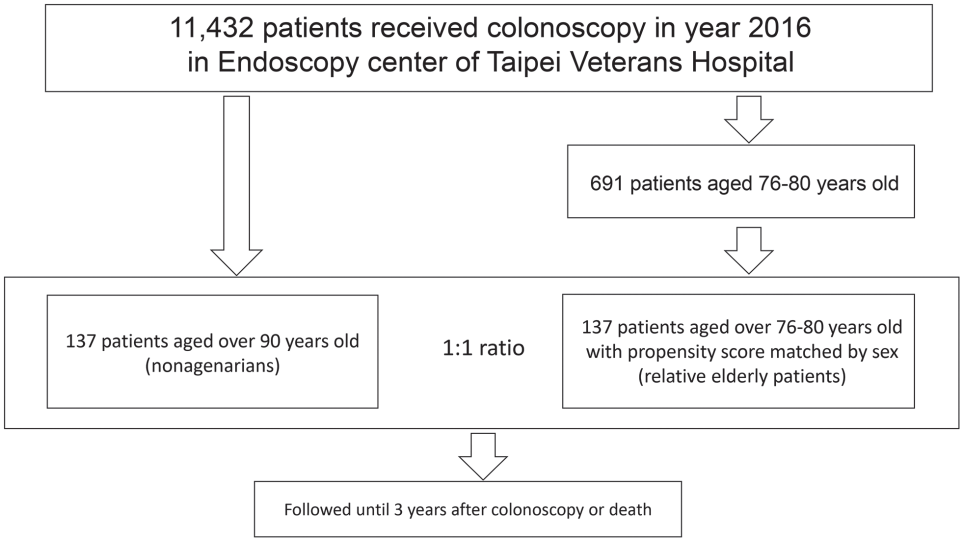

Fig. 1 Study flowchart.

window resulting from colonoscopy. Adverse events were classified as gastrointestinal events (such as bleeding or perforation), cardiopulmonary events (myocardial infarction, respiratory failure, symptomatic arrhythmia, or acute respiratory distress syndrome), or other potentially related adverse events (such as hypoglycemia or musculoskeletal injury). Bleeding was defined as rectal bleeding starting after completion of the colonoscopy to 30 days after the procedure with hypotension, decreased hemoglobin at least 2 g/dL from baseline, requirement of transfusion, prolonged hospitalization, hospitalization, emergency room visit, endoscopic hemostasis intervention, angiographic embolization, or surgery. Perforation was defined as any colonic perforation occurring from the start of colonoscopy up to 30 days after the completion of colonoscopy. Any emergency department visit within the 30-day window was also recorded. For clinical diagnoses, advanced neoplastic polyps were defined as an adenoma or sessile serrated polyp larger than 1 cm in size or any adenoma or sessile serrated polyp with high-grade dysplasia or >25% villous features (villous or tubulovillous histology). Nonadvanced neoplastic polyps included tubular adenomas (<1 cm in size) and sessile serrated adenomas (<1 cm). The colonoscopy findings were categorized as (1) CRC, (2) advanced neoplasia, (3) nonadvanced, and (4) benign lesions, such as colitis, diverticulosis, hyperplastic polyps, or hemorrhoids.[26] In the context of our study, the term benign denoted all nonneoplastic conditions, regardless of severity. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki.

The institutional review board of the medical center approved this study. Informed consent was waived by the institutional review board due to the retrospective nature of the study and the absence of obvious potential harm to the enrolled patients. The study was conducted according to the STROBE guidelines.

2.4. Statistical analysis

Variables in the two groups were compared using Student's *t* test for continuous variables and the x^2 test and Fisher's exact test for categorical variables where appropriate. Kaplan–Meier survival curves with log-rank tests were used for mortality analysis. Two-tailed p values < 0.05 were considered statistically significant. Statistical analysis was performed using the Statistical Package for the Social Sciences 26.0 (IBM Corp. Armonk, NY). Figures were created using GraphPad Prism 5 (GraphPad Corp, San Diego, CA).

3.RESULTS

3.1. Demographic data and procedural indications

During our study period, 137 consecutive nonagenarians underwent consecutive colonoscopies, and 137 consecutive relatively elderly patients receiving colonoscopy were enrolled as sex-matched controls. The mean age of the nonagenarians was 91.62 years, and 108 patients (78.8%) were male. The mean age of the relatively elderly patients was 76.66 years (Table 1). A higher proportion of ASA class III subjects and more inpatients were observed in the nonagenarians than in the relatively elderly patient controls (p < 0.001). Colonoscopy was more frequently performed due to low gastrointestinal tract bleeding in the nonagenarians than in the relatively elderly patients (Table 1). All the colonoscopies were completed without sedation in the nonagenarian group, and only a few colonoscopies were completed with sedation in the relatively elderly patient group according to the patient's wishes. The comorbidities and Charlson comorbidity score did not differ significantly between the two groups.

3.2. Performance of colonoscopy

The overall completion rate was significantly lower in the nonagenarians than in the relatively elderly patients (83.9% vs 93.4%, p = 0.013) (Table 2). The most common causes of incomplete colonoscopy were poor colon preparation in the nonagenarian group and bowel lumen blockage in the relatively elderly patient group. After adjustment for obstruction by colonic lesions or target lesions found during endoscopy, the adjusted colonoscopy completion rate was comparable in the nonagenarian and relatively elderly patient groups (92.0% vs 97.1%, p = 0.063).

Table 1

Demographic data, indications, and comorbidities in patients receiving colonoscopy

Variable	Nonagenarians (n = 137)	Relatively elderly patients (n = 137)	*p*
Demographic data (n, %)			
Age (y, SD)	91.62 ± 1.64	76.66 ± 1.45	<0.001
Sex (male)	108 (78.8%)	108 (78.8%)	1.000
ASA CLASS (class, SD)	2.34 ± 0.504	2.02 ± 0.680	<0.001
ASA class ≥ III	48 (35.0%)	33 (24.1%)	0.047
Inpatient status	55 (40.1%)	27 (19.7%)	<0.001
Sedation	0 (0.0%)	22 (16.1%)	<0.001
Indication for colonoscopy (n,%)			
Stool occult blood	23 (16.8%)	21 (15.3%)	0.742
Low gastrointestinal tract bleeding	35 (25.5%)	21 (15.3%)	0.036
Anemia	7 (5.1%)	4 (2.9%)	0.356
Altered bowel habit	16 (11.7%)	18 (13.1%)	0.714
Abdomen pain/fullness	9 (6.6%)	12 (8.8%)	0.496
Body weight loss	3 (2.2%)	1 (0.7%)	0.314
Colorectal cancer follow-up	27 (19.7%)	37 (27.0%)	0.153
Colorectal polyps follow-up	10 (7.3%)	13 (9.5%)	0.513
Colon tumor noted by other examination	5 (3.6%)	3 (2.2%)	0.473
Others[a]	2 (1.5%)	7 (5.1%)	0.090
Comorbidities (n, %)			
Hypertension	75 (54.7%)	87 (63.5%)	0.140
Diabetes mellitus	28 (20.4%)	35 (25.5%)	0.315
Ischemic heart disease	55 (40.1%)	45 (32.8%)	0.210
Cancer history	55 (40.1%)	63 (46.0%)	0.329
Chronic kidney disease	13 (9.5%)	20 (14.6%)	0.194
Chronic pulmonary disease	24 (17.5%)	19 (13.9%)	0.406
Old cerebrovascular event	9 (6.6%)	15 (10.9%)	0.200
Charlson score (score, SD)	3.64 ± 1.862	3.53 ± 2.18	0.655

ASA = American Society of Anesthesiologists; SD = standard deviation.
[a]Other indications included elevated tumor markers, r/o colon tumor obstruction, and check-ups due to a family history of colon cancer.

3.3. Bowel cleanliness

Bowel cleanliness was better in relatively elderly patients than in the nonagenarians (Table 2). A total of 76.6% of the nonagenarians and 86.9% of the relatively elderly patients achieved adequate bowel preparation (p = 0.029). Polyethylene glycol was the main bowel cleansing agent in both groups (83.2% vs 75.2%, p = 0.102). Sodium phosphate was more commonly used in the relatively elderly patients than in the nonagenarians (14.6% vs 4.4%, p = 0.004), and rectal enema was more commonly used in the nonagenarians than in the relatively elderly patients (8.0% vs 2.2%, p = 0.047).

3.4. Adverse events

The overall adverse events were <3%, with no difference between the two groups (p = 0.409) (Table 2). One patient in the nonagenarian group suffered acute respiratory distress syndrome 12 days after the colonoscopy, which resulted in death. Two other patients had a hypoglycemic condition and urinary

Table 2

Performance of colonoscopy and adverse events

Variable	Nonagenarians (n = 137)	Relatively elderly patients (n = 137)	*p*
Overall completion rate (n,%)[a]	115 (83.9%)	128 (93.4%)	0.013
Adjusted completion rate (n,%)[b]	126 (92.0%)	133 (97.1%)	0.063
Examined by experienced endoscopists	50 (36.5%)	81 (59.1%)	0.000
Reason of incompletion (n, %)			
Patient intolerance	4 (2.9%)	1 (0.7%)	0.555
Obstruction	5 (3.6%)	3 (30.0%)	0.660
Target lesion found	6 (4.4%)	3 (30.0%)	0.874
Poor colon preparation	7 (5.1%)	3 (2.2%)	0.918
Level of bowel cleaning (n, %)			
Adequate	105 (76.6%)	119 (86.9%)	0.029
Excellence	5 (3.6%)	6 (4.4%)	0.758
Good	53 (38.7%)	71 (51.8%)	0.029
Fair	47 (34.3%)	42 (30.7%)	0.519
Poor	32 (23.4%)	18 (13.1%)	0.029
Bowel cleansing agent (n, %)			
Polyethylene glycol	114 (83.2%)	103 (75.2%)	0.102
Sodium phosphate	6 (4.4%)	20 (14.6%)	0.004
Enema	13 (8.0%)	3 (2.2%)	0.047
Other	4 (2.9%)	11 (8.0%)	0.329
Overall adverse events, n (%)	4 (2.9%)	2 (1.5%)	0.409
Gastrointestinal events	0 (0.0%)	1 (0.7%)	0.316
Cardiopulmonary events	1 (0.7%)	1 (0.7%)	1.000
Other adverse events[c]	3 (2.2%)	0 (0.0%)	0.082
Postcolonoscopy 30-d mortality (n, %)	3 (2.2%)	2 (1.5%)	0.652

[a]Overall completion rate: rate of colonoscopy reaching the cecum or terminal ileum in all colonoscopies.
[b]Adjusted completion rate: rate of colonoscopy reaching cecum or terminal ileum, stopped by obstructing lesion or target lesion found in all colonoscopies.
[c]Other adverse events, including seizures, hypoglycemia, or urinary tract infections.

tract infection after the colonoscopy, and one patient had a seizure during the colonoscopy. One patient in the relatively elderly patient group had hypotension the day after the colonoscopy, and another patient had low gastrointestinal tract bleeding 7 days after the colonoscopy. All of the patients who suffered adverse events were inpatients. There were no postprocedural emergency department visits or unplanned hospitalizations in either group. However, five patients died within 30 days of the colonoscopy. Other than the patient who died of acute respiratory distress syndrome mentioned above, two patients died of malignancy, one patient died of ischemic bowel disease, and another patient died of preexisting aspiration pneumonia. All of the mortality cases were also inpatients.

3.5. Diagnostic yields

The diagnostic yields, including those of benign disease and neoplasia, were similar in the nonagenarians compared with the relatively elderly patients (Table 3). A total of 40.9% of the patients in the nonagenarian group had neoplasia. The incidences of advanced neoplasia and colon cancer were also comparable in both groups. The distributions of neoplasia and adenocarcinoma did not differ between the two groups. However, the polyps found in the nonagenarians were larger than those found in the relatively elderly patients.

3.6. Survival in the patients diagnosed with CRC

Twenty-four patients were diagnosed with CRC (Table 4). Of these patients, 12 nonagenarians and 7 relatively elderly patients received surgical resection of CRC within 30 days of the colonoscopy. The cancer staging, surgery rate, and survival benefit were comparable between the nonagenarians and the relatively elderly patients.

The nonagenarian CRC patients who received surgery had significant survival benefits compared to the patients who did not receive surgery (p = 0.0352) (Fig. 2). Significant survival benefits were also observed in the relatively elderly patients who received surgery compared to the nonsurgery group (p = 0.0023). The overall cancer staging also did not significantly differ between the nonagenarians who had surgery and those who did not (p = 0.326).

The median survival time of the patients who received surgical resection was longer than that of the patients who did not receive surgery in the nonagenarian group and the relatively elderly patient group (Table 4). The risk of death was lower in the patients who received surgery than in the patients who were treated conservatively in both groups.

4.DISCUSSION

This study was a retrospective case-control study that evaluated the performance and safety of all colonoscopy examinations and treatments in patients aged >90 years and compared this group to patients aged 76–80 years. To the best of our knowledge, this study is the largest and oldest cohort examined. The performance of colonoscopy in the nonagenarian patients was as good as that in the relatively elderly patients in our study. Over 95% of the nonagenarians had abnormalities found during colonoscopy, while more than one-third of these abnormalities were neoplastic. The adverse event rate and colonoscopy-related mortality were low and comparable in the nonagenarian and relatively elderly patient groups. Of the nonagenarian patients with CRC found via colonoscopy, most of the patients received curative surgery, which resulted in better survival. Colonoscopy in nonagenarians is safe and provides clinical benefits.

Since advanced age is a risk factor for major low gastrointestinal tract bleeding,[27,28] more of the nonagenarians than relatively elderly patients received colonoscopy due to low gastrointestinal tract bleeding, as expected. More of the nonagenarians were inpatients, which suggests that elderly people may be less likely to receive a colonoscopy unless indicated as necessary. The comorbidity categories were comparable between the two groups, but the ASA class was higher in the nonagenarian group than in relatively elderly group. The higher inpatient rate and higher ASA class suggest that the clinical status of the nonagenarians was relatively worse than that of the relatively elderly patients.

The clinical status was more severe in the nonagenarians than in the relatively elderly patients, and the colonoscopy completion rate in the nonagenarians was relatively lower than the requested average completion rate.[29] However, we found that after adjustment for obstructing masses and target lesions found, the colonoscopy completion rate was >90% in the nonagenarians and relatively elderly patients and did not differ between the two groups, and these findings were contrary to those of previous studies.[15] The high colonoscopy completion rate may be related to the lower use of sedative colonoscopy in our study. The anesthesia risk was suggested to be over 10 times more frequent in patients >85 years than in patients aged 66–69 years old.[16] None of the nonagenarians received anesthesia in the present study. Notably, only a limited number of patients in both groups were intolerant to colonoscopy, which led to incomplete colonoscopy, even without sedation. Dedicated colonoscopy skills, carbon dioxide insufflation or the water exchange method may also be used to improve patients' tolerance during colonoscopy.[30–32]

Bowel clearance quality was better in the relatively elderly patients than in the nonagenarians. The adequate bowel

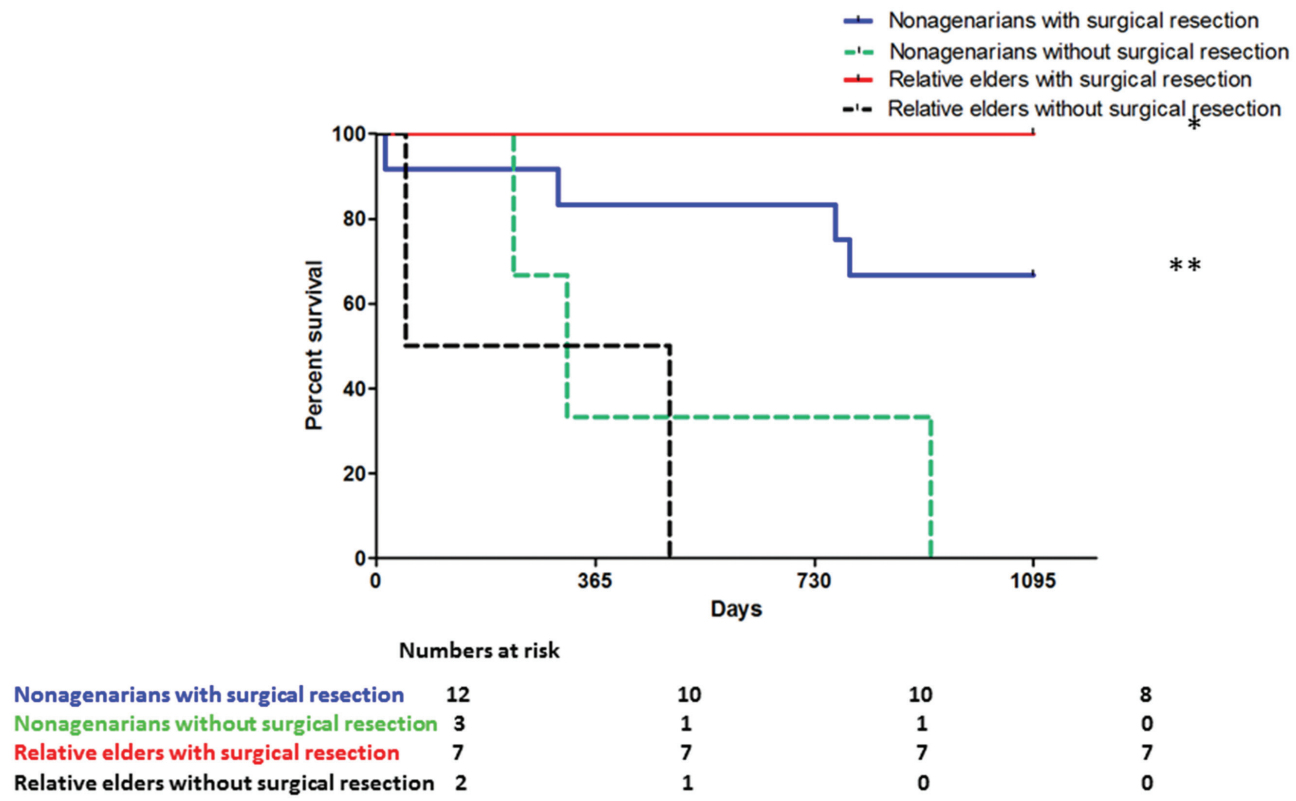

Fig. 2 Survival curves of patients diagnosed with colorectal cancer via colonoscopy classified as nonagenarians or relatively elderly patients and surgical resection or without surgical resection (n = 24). *$p < 0.01$ between relatively elderly patients with surgical resection and relatively elderly patients without surgical resection. **$p < 0.05$ between nonagenarians with surgical resection and nonagenarians without surgical resection.

clearance rate was <90% in both groups, which is superior to previous studies.[15,21] Polyethylene glycol was the main bowel cleansing agent in both groups. The use of polyethylene glycol for bowel preparation is considered safe in the general geriatric population,[33] and sodium phosphate has a higher risk for renal toxicity, especially for the elderly population.[34] Therefore, a significantly lower proportion of the nonagenarians received sodium phosphate for bowel preparation than the relatively elderly patients in this study. Notably, enema was more frequently used in the nonagenarians than in the relatively elderly patients. This difference may be due to the higher incidence of lower gastrointestinal bleeding in the nonagenarians, and polyethylene glycol was less likely to be administered in a timely manner in the nonagenarians in urgent conditions.

The overall adverse events were low in the nonagenarian group and the relatively elderly patient group. We evaluated the adverse events thoroughly by reviewing inpatient records, emergency room medical records, and outpatient clinic records, where outpatient follow-up at approximately 1 week and 1 month after discharge was routine clinical practice. The adverse events included in this study were not limited only to severe adverse events as in a previous study[21] but also included all potential adverse events related or not related to colonoscopy. This result was unlike previous opinions that adverse events may be more commonly encountered in older patients[35] and may be related to a high ASA class.[36] The nonagenarian group had a high ASA class but did not have increased adverse events. Performing nonsedation colonoscopy for nonagenarians may diminish the occurrence of anesthesia-related adverse events.[16] No colonoscopy-related mortality was observed. The low incidence of adverse events and colonoscopy-related mortality suggests that advanced age is not a contraindication for colonoscopy.

Colonoscopy revealed neoplasias in >40% of the nonagenarians. For the nonagenarian patients diagnosed with CRC, >80% received curative surgery. Our study showed that the nonagenarians who received surgical treatment for CRC management had longer survival than the patients who did not receive surgical treatment, which was similar to the relatively elderly patients. The performance of colonoscopy in nonagenarians produced similar diagnostic yields and further intervention, similar to the relatively elderly patients. Age is not a barrier for the diagnostic and therapeutic objectives of colonoscopy or CRC surgery.[37]

Advanced age has long been considered a contraindication for colonoscopy because colonoscopy was suspected to be linked with a higher risk of side effects.[16,18] Since these patients have a limited life expectancy, the benefits and potential for harm in receiving colonoscopy must be justified. However, as the overall population ages, the need for colonoscopy in the elderly population is also increasing. The general recommendation is to stop screening for CRC in patients who have an estimated life expectancy of <10 years.[38] However, for nonagenarians who are expected to live >100 years, colon cancer surveillance may be considered based on personalized management.[39] Recent noninvasive novel diagnostic tools, including colon capsule endoscopy,[20] computed tomography colography[19] or prepless x-ray capsules,[40] were developed for colon polyp detection. However, laxative use, radiation, and their inability for histopathological diagnosis limit their use in clinical practice. Colonoscopy remains the most efficient and accurate method for the diagnosis and treatment of colorectal lesions. For patients who have active bleeding, warning signs, or other suitable indications for colonoscopy, an age limit should not be used to prevent patients from receiving colonoscopy. The present study demonstrated that colonoscopy in nonagenarians had a high safety profile

Table 3

Diagnostic yields and findings of colonoscopy

Variable	Nonagenarians (n = 137)	Relatively elderly patients (n = 137)	*p*
Overall benign disease (n, %)			
Colitis	7 (5.1%)	3 (2.2%)	0.198
Diverticulosis	9 (6.6%)	15 (10.9%)	0.200
Hyperplastic polyps	3 (2.2%)	10 (7.3%)	0.047
Hemorrhoids	58 (42.3%)	52 (38.0%)	0.460
Inflammation	6 (4.4%)	8 (5.8%)	0.583
Neoplasia (n, %)	56 (40.9%)	52 (38.0%)	0.621
Advanced neoplasia[a]	25 (18.2%)	17 (12.4%)	0.180
High-grade dysplasia	2 (1.5%)	4 (2.9%)	0.409
Colon rectal adenocarcinoma	15 (10.9%)	9 (6.6%)	0.272
Lymphoma[b]	2 (1.5%)	0 (0.0%)	0.156
Nonadvanced neoplasia	29 (21.2%)	35 (25.5%)	0.392
Negative finding	5 (3.6%)	10 (7.3%)	0.184
All neoplasia number and sizes			
Polyp number (number, SD)	1.55 ± 0.95	1.95 ± 2.50	0.282
Polyp size (cm, SD)	1.79 ± 1.76	1.00 ± 1.33	0.006
All neoplasia location (n,%)			
Cecum	4 (7.7%)	7 (11.1%)	0.456
Ascending colon	13 (25.0%)	19 (30.6%)	0.365
Transverse colon	9 (17.3%)	12 (19.0%)	0.641
descending colon	10 (19.2%)	12 (19.4%)	0.835
Sigmoid colon	19 (36.5%)	13 (21.0%)	0.114
Rectum	18 (34.6%)	9 (14.5%)	0.023
Adenocarcinoma location (n, %)[c]			
Ascending colon	3 (20%)	2 (20.0%)	1.000
Transverse colon	1 (6.7%)	1 (10.0%)	0.763
descending colon	2 (13.3%)	3 (30.0%)	0.307
Sigmoid colon	6 (40%)	4 (40.0%)	1.000
Rectum	6 (40.0%)	3 (30.0%)	0.610
Rate of lesions not receiving histopathological evaluation (n, %)	19 (13.9%)	6 (4.4%)	0.006
Use of antiplatelets	13 (68.4%)	4 (66.7%)	0.936
Poor preparation	3 (15.8%)	1 (16.7%)	0.959
Intolerance	1 (5.3%)	0 (0.0%)	0.566
Patient's or patient's family refusal	2 (10.5%)	1 (16.7%)	0.687

[a]Pathology-proven adenoma polyp >1 cm in size or any adenoma polyp with high-grade dysplasia, >25% villous features (villous or tubulovillous histology), or carcinoma.

[b]One case of peripheral T cell lymphoma and one case of mantle cell lymphoma.

[c]Three nonagenarians and one relatively elderly patient had synchronous tumors in different locations of the colon.

Table 4

Surgery and death in patients diagnosed with CRC via colonoscopy

	Nonagenarians (n = 15)	Relatively elderly patients (n = 9)	*p*
Clinical T staging, no. (%)			0.912
cT1	1 (6.7%)	1 (11.1%)	
cT2	3 (20%)	1 (11.1%)	
cT3	7 (46.7%)	5 (55.6%)	
cT4	4 (26.7%)	2 (22.2%)	
Clinical N staging, no. (%)			0.449
N0	9 (60.0%)	3 (33.3%)	
N1	3 (20.0%)	3 (33.3%)	
N2	3 (20.0%)	3 (33.3%)	
Clinical M staging, no. (%)			0.572
M0	13 (86.7%)	7 (77.8%)	
M1	2 (13.3%)	2 (22.2%)	
AJCC 8th stage			0.326
Stage 1–2	8 (53.3%)	*2 (22.2%)*	
Stage 3	5 (33.3%)	5 (55.6%)	
Stage 4	2 (13.3%)	2 (22.2%)	
Received surgery for CRC (n, %)	12 (80.0%)	7 (77.8%)	0.897
Death (n, %)	7 (46.7%)	2 (22.2%)	0.134
Median survival in patients with surgery (d)	Not met	Not met	0.101
Median survival in patients without surgery (d)	318	268.5	0.586
HR of death in patients with surgery versus without surgery (HR, 95% CI)	0.1044 (0.01275–0.8529)	0.0029 (0.0001–0.1145)	0.038

CI = confidence interval; CRC = colorectal cancer; HR = hazard ratio.

and a high diagnostic yield, and it provided the basis for further treatment of patients diagnosed with CRC. For patients with multiple comorbidities or critical illness, detailed precolonoscopy evaluations will help establish a procedure plan and maintain safety. Therefore, it is feasible to perform colonoscopy in patients >90 years of age.

Some limitations exist in the present study. Since this study was retrospective in design, nonagenarians with poor health status or multiple comorbidities may not be referred for colonoscopy. However, 40% of the enrolled nonagenarians were inpatients, and 35% of the nonagenarians had high ASA class III, which suggested that many of the enrolled nonagenarians had an impaired health status rather than being generally healthy. With physicians' adequate evaluation and management, nonagenarians can still receive colonoscopy for diagnosis and treatment if clinically indicated. Second, the ASA class of the patients receiving nonsedation therapy was retrospectively analyzed, which may have led to underestimation of ASA. Third, only a few patients did not receive surgery after CRC diagnosis in the study, which may have led to statistical error, with imbalanced patients between the surgery and nonsurgery groups. However, the majority of nonagenarians diagnosed with CRC successfully received surgery, suggesting that it is still feasible for advanced-age patients to receive colonoscopy and surgery in the management of CRC after physician evaluation. Finally, the present study only enrolled patients from one medical center, which limits the generalizability of our results. Further larger multicenter studies are needed to validate the safety and clinical benefits of colonoscopy in patients older than 90 years.

In conclusion, colonoscopy in patients older than 90 years is generally safe with good performance. Nonagenarians diagnosed with CRC via colonoscopy may also be treated with surgery, which showed a survival benefit.

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REFERENCES

1. Dekker E, Tanis PJ, Vleugels JLA, Kasi PM, Wallace MB. Colorectal cancer. *Lancet* 2019;**394**:1467–80.
2. Arnold M, Sierra MS, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global patterns and trends in colorectal cancer incidence and mortality. *Gut* 2017;**66**:683–91.
3. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2018;**68**:394–424.
4. Levin B, Lieberman DA, McFarland B, Smith RA, Brooks D, Andrews KS, et al; American Cancer Society Colorectal Cancer Advisory Group;

US Multi-Society Task Force; American College of Radiology Colon Cancer Committee. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. *CA Cancer J Clin* 2008;**58**:130–60.
5. Su MY, Hsu CM, Lin CJ, Ho YP, Chiu CT, Chen PC, et al. Endoscopic treatment of colorectal neoplasms: a simple and safe procedure to lower the incidence of colorectal cancers. *Dig Dis Sci* 2008;**53**:1297–302.
6. Nishihara R, Wu K, Lochhead P, Morikawa T, Liao X, Qian ZR, et al. Long-term colorectal-cancer incidence and mortality after lower endoscopy. *N Engl J Med* 2013;**369**:1095–105.
7. Rex DK, Boland CR, Dominitz JA, Giardiello FM, Johnson DA, Kaltenbach T, et al. Colorectal cancer screening: recommendations for physicians and patients from the U.S. Multi-Society Task Force on Colorectal Cancer. *Gastrointest Endosc* 2017;**86**:18–33.
8. Cairns SR, Scholefield JH, Steele RJ, Dunlop MG, Thomas HJ, Evans GD, et al; British Society of Gastroenterology; Association of Coloproctology for Great Britain and Ireland. Guidelines for colorectal cancer screening and surveillance in moderate and high risk groups (update from 2002). *Gut* 2010;**59**:666–89.
9. Corley DA, Jensen CD, Marks AR, Zhao WK, de Boer J, Levin TR, et al. Variation of adenoma prevalence by age, sex, race, and colon location in a large population: implications for screening and quality programs. *Clin Gastroenterol Hepatol* 2013;**11**:172–80.
10. Harewood GC, Lawlor GO, Larson MV. Incident rates of colonic neoplasia in older patients: when should we stop screening? *J Gastroenterol Hepatol* 2006;**21**:1021–5.
11. Day LW, Walter LC, Velayos F. Colorectal cancer screening and surveillance in the elderly patient. *Am J Gastroenterol* 2011;**106**:1197–206.
12. Loffeld RJ, Liberov B, Dekkers PE. Yearly diagnostic yield of colonoscopy in patients age 80 years or older, with a special interest in colorectal cancer. *Geriatr Gerontol Int* 2012;**12**:298–303.
13. Shrestha LB. Population aging in developing countries. *Health Aff (Millwood)* 2000;**19**:204–12.
14. Department of Household Registration Affairs, MOI. Population data quarterly publication. Available at http://www.ris.gov.tw/app/en/3912. Accessed August 21, 2020.
15. Cha JM, Kozarek RA, La Selva D, Gluck M, Ross A, Chiorean M, et al. Risks and benefits of colonoscopy in patients 90 years or older, compared with younger patients. *Clin Gastroenterol Hepatol* 2016;**14**:80–6. e1.
16. Cooper GS, Kou TD, Rex DK. Complications following colonoscopy with anesthesia assistance: a population-based analysis. *JAMA Intern Med* 2013;**173**:551–6.
17. Connor A, Tolan D, Hughes S, Carr N, Tomson C. Consensus guidelines for the safe prescription and administration of oral bowel-cleansing agents. *Gut* 2012;**61**:1525–32.
18. Grossberg LB, Papamichael K, Leffler DA, Sawhney MS, Feuerstein JD. Patients over age 75 are at increased risk of emergency department visit and hospitalization following colonoscopy. *Dig Dis Sci* 2020;**65**:1964–70.
19. Zalis ME, Blake MA, Cai W, Hahn PF, Halpern EF, Kazam IG, et al. Diagnostic accuracy of laxative-free computed tomographic colonography for detection of adenomatous polyps in asymptomatic adults: a prospective evaluation. *Ann Intern Med* 2012;**156**:692–702.
20. Van Gossum A, Munoz-Navas M, Navas MM, Fernandez-Urien I, Carretero C, Gay G, et al. Capsule endoscopy versus colonoscopy for the detection of polyps and cancer. *N Engl J Med* 2009;**361**:264–70.
21. Shafrir A, Koslowsky B, Wengrower D, Goldin E, Livovsky DM. Colonoscopy in nonagenarians is safe and may be associated with clinical benefit. *J Am Geriatr Soc* 2019;**67**:1158–63.
22. Department of Economic and Social Affairs PD, United States 2019. World population ageing 2019: highlights. Available at http://creativecommons.org/licenses/by/3.0/igo/.
23. Johnson DA, Barkun AN, Cohen LB, Dominitz JA, Kaltenbach T, Martel M, et al; US Multi-Society Task Force on Colorectal Cancer. Optimizing adequacy of bowel cleansing for colonoscopy: recommendations from the US multi-society task force on colorectal cancer. *Gastroenterology* 2014;**147**:903–24.
24. Sankar A, Johnson SR, Beattie WS, Tait G, Wijeysundera DN. Reliability of the American Society of Anesthesiologists physical status scale in clinical practice. *Br J Anaesth* 2014;**113**:424–32.
25. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;**40**:373–83.
26. Lieberman DA, Weiss DG, Bond JH, Ahnen DJ, Garewal H, Chejfec G. Use of colonoscopy to screen asymptomatic adults for colorectal cancer. Veterans Affairs Cooperative Study Group 380. *N Engl J Med* 2000;**343**:162–8.
27. Oakland K, Chadwick G, East JE, Guy R, Humphries A, Jairath V, et al. Diagnosis and management of acute lower gastrointestinal bleeding: guidelines from the British Society of Gastroenterology. *Gut* 2019;**68**:776–89.
28. Oakland K, Guy R, Uberoi R, Hogg R, Mortensen N, Murphy MF, et al; UK Lower GI Bleeding Collaborative. Acute lower GI bleeding in the UK: patient characteristics, interventions and outcomes in the first nationwide audit. *Gut* 2018;**67**:654–62.
29. Rees CJ, Thomas Gibson S, Rutter MD, Baragwanath P, Pullan R, Feeney M, et al; British Society of Gastroenterology, the Joint Advisory Group on GI Endoscopy, the Association of Coloproctology of Great Britain and Ireland. UK key performance indicators and quality assurance standards for colonoscopy. *Gut* 2016;**65**:1923–9.
30. Hsu WF, Hu WH, Chen YN, Lai HH, Chen MK, Chang LC, et al. Carbon dioxide insufflation can significantly reduce toilet use after colonoscopy: a double-blind randomized controlled trial. *Endoscopy* 2014;**46**:190–5.
31. Cadoni S, Hassan C, Frazzoni L, Ishaq S, Leung FW. Impact of water exchange colonoscopy on endoscopy room efficiency: a systematic review and meta-analysis. *Gastrointest Endosc* 2019;**89**:159–67.e13.
32. Bourke MJ, Rex DK. Tips for better colonoscopy from two experts. *Am J Gastroenterol* 2012;**107**:1467–72.
33. Neilson LJ, Thirugnanasothy S, Rees CJ. Colonoscopy in the very elderly. *Br Med Bull* 2018;**127**:33–41.
34. Lin ZW, Hsu CM, Cheng HT, Su MY, Ho YP, Chen TH, et al. The diagnostic yield and risk of screening colonoscopy in geriatric subjects older than 80 years. *Adv Dig Med* 2020; **7**: 63–7.
35. Yoong KK, Heymann T. Colonoscopy in the very old: why bother? *Postgrad Med J* 2005;**81**:196–7.
36. Enestvedt BK, Eisen GM, Holub J, Lieberman DA. Is the American Society of Anesthesiologists classification useful in risk stratification for endoscopic procedures? *Gastrointest Endosc* 2013;**77**:464–71.
37. Mazzari A, Tomaiuolo P, Perrone F, Sicoli F, Crucitti A. Surgical management of colorectal cancer in the elderly patient. In: Crucitti A, editor. *Surgical management of elderly patients*. 1st ed. Cham: Springer; 2018, p. 229–39.
38. Qaseem A, Denberg TD, Hopkins RH Jr, Humphrey LL, Levine J, Sweet DE, et al; Clinical Guidelines Committee of the American College of Physicians. Screening for colorectal cancer: a guidance statement from the American College of Physicians. *Ann Intern Med* 2012;**156**:378–86.
39. Nee J, Chippendale RZ, Feuerstein JD. Screening for colon cancer in older adults: risks, benefits, and when to stop. *Mayo Clin Proc* 2020;**95**:184–96.
40. Gluck N, Half EE, Bieber V, Schwartz D, Ron Y, Gralnek I, et al. Novel prep-less X-ray imaging capsule for colon cancer screening: a feasibility study. *Gut* 2019;**68**:774–5.