

Original Investigation

Surveillance Colonoscopy in Elderly Patients A Retrospective Cohort Study

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IMPORTANCE The risks and benefits of surveillance colonoscopy in elderly patients have not been well characterized.

OBJECTIVE To investigate the relative impact of surveillance colonoscopy in elderly patients compared with a reference cohort.


DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study from 2001 through 2010 of patients 50 years and older undergoing surveillance colonoscopy for a history of colorectal cancer (CRC) or adenomatous polyps at an integrated health care system in southern California. Patients were followed up from the surveillance examination until CRC diagnosis, death, disenrollment, IBD diagnosis, or study end date (December 31, 2010).

MAIN OUTCOMES AND MEASURES The primary outcome measure was incidence of CRC detected following surveillance colonoscopy. The secondary outcome was risk of procedure defined as postprocedure hospitalization within 30 days. Cox regression and multivariable logistic regression analyses were used to determine the impact of age on CRC incidence on surveillance examination as well as postprocedure hospitalization, respectively.

RESULTS The study cohort included 4834 elderly patients (age ≥ 75 years; 55.8% male) (median surveillance age, 79 years) and 22 929 individuals in the reference group (age 50-74 years; 57.7% male) (median surveillance age, 63 years). A total of 373 cancers were detected following surveillance colonoscopy (368 in the reference group and 5 among the elderly patients). There were a total of 711 postprocedure hospitalizations (184 in the reference group and 527 among the elderly patients). The CRC incidence among elderly patients undergoing surveillance was 0.24 per 1000 person-years vs 3.61 per 1000 person-years in the reference population ($P < .001$). In Cox regression analysis, the hazard ratio for CRC in the elderly patients compared with the reference group was 0.06 (95% CI, 0.02-0.13) ($P < .001$) after adjusting for comorbid illness, sex, and race/ethnicity. In logistic regression analysis, age 75 years and older was independently associated with increased risk of postprocedure hospitalization (adjusted odds ratio, 1.28 [95% CI, 1.07-1.53]; $P = .006$). Charlson score of 2 was also independently associated with increased risk of postprocedure hospitalization (adjusted odds ratio, 2.54 [95% CI, 2.06-3.14]; $P < .001$).

CONCLUSIONS AND RELEVANCE A low incidence of CRC and relatively high rate of postprocedure hospitalization were found among elderly patients undergoing surveillance colonoscopy. Recommendations for ongoing surveillance in the elderly population should take into consideration the impact of comorbid illness and increasing age on the anticipated risks and benefits of colonoscopy.

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Colorectal cancer (CRC) is the second leading cause of cancer-related deaths in the United States. The incidence of CRC increases with age. Current evidence-based guidelines recommend screening for persons at average risk starting at the age of 50 years. The American College of Physicians guideline recommends against further screening for adults after age 75 years; however, the US Preventative Services Task Force guideline recommends additional individualized decision making about colorectal cancer screening between ages 75 and 85 years.^{1,2} Colonoscopy is universally recommended for surveillance of individuals with a personal history of adenomatous polyps or CRC.^{3,4} However, current guidelines have not addressed the issue of when, if ever, surveillance should be stopped.^{5,6}

To date, few studies have addressed surveillance colonoscopy in the elderly population (age ≥ 75 years).^{3,5,7} This issue is of increasing importance because the size of this age cohort is expected to increase in the coming years.^{3,8} Studies have examined the risks of having colonoscopies in elderly patients,⁹⁻¹⁷ as well as the overall benefits of continuing surveillance following polypectomy or resection of a CRC.¹⁸⁻²⁴ However, elderly patients represent a unique patient population with specific health care needs, and it is not yet established at which point risk of a colonoscopy might potentially outweigh expected benefits of ongoing surveillance.

The objective of this study was to determine how the risks and benefits of surveillance colonoscopy vary between the elderly and younger patients. We characterized the benefit of surveillance examination as the incidence of CRC detected and characterized risk as the incidence of hospitalizations within 30 days of colonoscopy.

Methods

Study Design, Setting, and Participants

This retrospective cohort study from 2001 through 2010 was approved by the institutional review board of Kaiser Permanente Southern California. Kaiser Permanente Southern California (KPSC) is an integrated health care system that provides comprehensive health services for approximately 3.6 million residents of southern California. KPSC also provides care for Medicare patients through Medicare Advantage. The population served by KPSC is socioeconomically

diverse and broadly representative of the racial/ethnic groups living in southern California. Members enroll through the Kaiser Foundation Health Plan for prepaid health care insurance, including pharmaceutical benefits. KPSC is one of Kaiser Permanente's largest regions, which provides care at 15 hospitals and more than 200 medical offices by a partnership of over 6000 physicians who comprise the entire range of medical specialists including 13 gastroenterology groups.

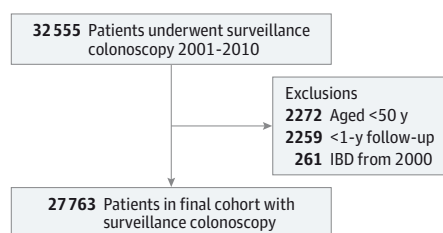
The study population included individuals who underwent surveillance colonoscopy during 2001 through 2010. All individuals 50 years and older at the time of the procedure with a prior diagnosis of CRC (V10.05) or adenomatous polyps (V12.72) were potentially eligible for study inclusion. Surveillance colonoscopy procedures were identified by combining *Current Procedural Terminology* (CPT) for colonoscopy procedure and *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes for history of CRC or polyp. Specifically, both CPT and ICD-9-CM V codes had to be assigned at the time of the procedure. An index date was then determined by the earliest surveillance examination. Baseline clinical and demographic information was obtained dating back 1 year from the index date (for codes, see eAppendix 2 in the Supplement). Individuals with less than 1 year of enrollment prior to the index date and those with inflammatory bowel disease (IBD) were excluded from the study. After assembling the study population, the cohort was stratified into 2 groups: elderly surveillance cohort (defined as age ≥ 75 years) vs reference surveillance cohort (defined as age 50-74 years). See Figure 1 for a study diagram.

Study Outcomes and Measures

To identify new or recurrent CRC cases, we cross-referenced the unique medical record identifier of each patient with a prospectively maintained internal cancer registry. The registry contains data on all patients diagnosed or treated for a new cancer since 1988. Cancer case ascertainment in this registry has been validated with high sensitivity ($>99\%$) because reporting of cancers is mandated under state law and abstracts of patients with cancer are sent to the State of California Cancer Registry and the National Cancer Institute Surveillance, Epidemiology and End Results (SEER) program. Patients were followed up from the surveillance examination until CRC diagnosis, death, disenrollment, IBD diagnosis, or study end date (December 31, 2010).

Potential risks associated with surveillance colonoscopy were measured as hospitalization within 30 days of outpatient surveillance colonoscopy. Adverse events leading to hospitalization were categorized as procedure related, other gastrointestinal disorder, and other causes based on individual medical record review of discharge diagnoses and discharge summaries. Procedure-related admissions included principal diagnosis of gastrointestinal tract hemorrhage, cardiac arrhythmia, or perforation. Admission related to gastrointestinal disorder or other nonprocedural-related, nongastrointestinal-related causes are provided in eTables 1 to 4 in the Supplement.

Figure 1. Study Diagram of Selection Process for Cohort Group



IBD indicates inflammatory bowel disease.

Statistical Analysis

Summary Statistics and Demographics

Means of quantitative variables, age, length of follow-up, and length of stay were compared between the elderly and reference cohorts using 2-sample *t* tests. For purpose of analysis, age was categorized into 50 to 74 years and 75 years and older and into 50 to 54, 55 to 59, 60 to 64, 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 years and older. Sex, race/ethnicity, Charlson comorbidity score (categorized into 0, 1, 2, and ≥ 3), and risk factors for CRC (dichotomized into “0” and “1,” with “0” meaning absence of risk factor) were compared using χ^2 tests or Fisher exact tests. All statistical tests were 2-sided, and $P < .05$ was considered significant. All analyses were conducted using SAS Enterprise Guide Version 4.3 (SAS Institute Inc).

CRC Incidence

We calculated CRC incidence density based on person-time at risk for each of the individual cohorts. To examine if CRC incidence varied with age, we first calculated a constant person-year incidence rate for the reference population (age <75 years) and elderly cohort (age ≥ 75 years) by dividing number of CRC cases by person-years of follow-up. Then we examined the CRC incidence more precisely by categorizing patients into 6 age groups (50-54, 55-59, 60-64, 65-69, 70-74, and ≥ 75 years). For each age group, we plotted a crude cumulative incidence curve using the Kaplan-Meier method and compared the curves using the log-rank test. We also performed multivariable Cox proportional hazards regression to assess age differences in incidence of CRC, adjusted for race/ethnicity, sex, personal history of CRC vs history of polyps, Charlson comorbidity score, and risk factors of CRC including family history of CRC or polyps, alcohol abuse (305.0X), tobacco use (305.1X, V15.82; includes current and history of tobacco use), nonsteroidal anti-inflammatory drug use (V58.64), as well as obese and overweight status (278.X, persons with body mass index ≥ 25 [calculated as weight in kilograms divided by height in meters squared]). These variables were selected based on availability of ICD-9-CM codes to reduce potential confounders and include risk factors for CRC per literature review.^{10,25}

Postprocedure Hospitalization

For analysis of postprocedure hospitalization, we included patients with at least 30 days of follow-up after their surveillance examination. We calculated the incidence rate ratio of hospitalization following surveillance colonoscopy based on cumulative incidence of unplanned hospitalizations stratified by age. We compared the risk of postprocedure hospitalization within 30 days between age groups 75 years and older or 75 to 79, 80 to 85, and 85 years and older vs 50 to 74 years using logistic regression. We incorporated the same covariates in the logistic regression analysis as in the aforementioned Cox regression analysis. In addition to the overall rate of hospitalization, we calculated separate incidence rates for procedure-related and gastrointestinal complications, as well as all-cause hospitalizations.

Results

Study Population

A total of 27 763 subjects were identified after excluding 261 with IBD and 2259 without 1 year of prior enrollment (Figure 1). **Table 1** gives the characteristics of the study cohort. Over 82% (22 929) of the study cohort were categorized into the reference cohort (age 50-74 years at surveillance colonoscopy), with a mean age of 63.2 years compared with a mean age 79.6 years in the elderly cohort. Compared with the reference cohort, the elderly group comprised more non-Hispanic whites (68.5 vs 56.0%) and had higher comorbidities (Charlson index ≥ 2 , 40.2% vs 22.5%). The 2 groups had similar distributions of CRC risk factors except that the elderly group had lower rates of overweight and/or obesity (17.5% vs 21.9%) and family history of CRC and/or polyps (10.6% vs 14.4%). Follow-up surveillance colonoscopy was performed for 20.5% (n = 992) in the elderly cohort with a personal history of CRC compared with 9.1% (n = 2081) in the reference cohort ($P < .001$ for all). The overall mortality for patients 75 years and older (50.7 [95% CI, 47.7-53.8] per 1000 person-years) was 4 times higher than the mortality rate of patients aged 50 to 74 years (12.7 [95% CI, 12.0-13.4] per 1000 person-years). See eTables 5 and 6 in the Supplement for characteristics based on CRC or polyp history and sex, respectively.

Incidence of CRC After Surveillance Examination

During a mean follow-up period of 4.3 years, a total of 373 CRCs were detected, 368 in the reference group and 5 among patients 75 years and older. Of the CRCs detected, 43 patients had a history of CRC compared with 330 patients with a history of polyp (see eTable 5 in the Supplement). Mean follow-up for the reference cohort was 53.4 months compared with 51.6 in the elderly cohort ($P < .001$).

The age-stratified incidence rates of CRC are summarized in the eFigure in the Supplement. With a total of 122 802.2 person-years of follow-up, the overall CRC incidence was 3.04 per 1000 person-years. The incidence among the elderly patients was lower at 0.24 per 1000 person-years compared with the incidence in the reference cohort of 3.61 per 1000 person-years ($P < .001$). This finding was consistent across both sexes (eTable 7 in the Supplement).

Kaplan-Meier Curve and Cox Regression Analysis

Cumulative incidence curves of CRC between the reference and elderly cohort are depicted in **Figure 2**. There was a significantly lower incidence of CRC detected in the elderly cohort compared with the reference cohort (log rank, $P < .001$). Hazard ratios (HRs) from unadjusted and adjusted Cox regression models are summarized in **Table 2**. The analysis included adjustment for race/ethnicity, sex, personal history of CRC vs history of polyps, Charlson comorbidity score, and CRC risk factors. The HR for CRC in the elderly cohort compared with the reference surveillance population was 0.06 (95% CI, 0.02-0.13). In addition to age, patients with Charlson score of 3 or greater were twice as

Table 1. Demographics and Characteristics of Elderly and Young Cohort Groups

	Age at Surveillance Colonoscopy, No. (%)			
Characteristic	<75 y (n = 22 929)	≥75 y (n = 4834)	Total (n = 27 763)	P Value
Age at surveillance colonoscopy				
Mean (SD), y	63.2 (6.77)	79.6 (3.53)	66.0 (8.88)	<.001
Median (range), y	63.4 (57.7-68.8)	78.8 (76.8-81.6)	65.7 (59.0-72.5)	
Range, y	50.0-75.0	75.0-98.4	50.0-98.4	
Age group, y				
50-54	3398 (14.8)	0	3398 (12.2)	<.001
54-59	4479 (19.5)	0	4479 (16.1)	
60-64	5270 (23.0)	0	5270 (19.0)	
64-69	5229 (22.8)	0	5229 (18.8)	
70-74	4553 (19.9)	0	4553 (16.4)	
75-79	0	2996 (62.0)	2996 (10.8)	
80-84	0	1412 (29.2)	1412 (5.1)	
≥85	0	426 (8.8)	426 (1.5)	
Sex				
Male	13 241 (57.7)	2698 (55.8)	15 939 (57.4)	.01
Female	9688 (42.3)	2136 (44.2)	11 824 (42.6)	
Race/ethnicity				
Asian/Pacific Islander	1943 (8.5)	292 (6.0)	2235 (8.1)	<.001
Black	2680 (11.7)	508 (10.5)	3188 (11.5)	
Hispanic	3353 (14.6)	514 (10.6)	3867 (13.9)	
Other/unknown	2116 (9.2)	211 (4.4)	2327 (8.4)	
White	12 837 (56.0)	3309 (68.5)	16 146 (58.2)	
Personal history of polyp or CRC				
CRC	2081 (9.1)	992 (20.5)	3073 (11.1)	<.001
Polyp	20 848 (90.9)	3842 (79.5)	24 690 (88.9)	
Category of Charlson index				
0	14 033 (61.2)	2056 (42.5)	16 089 (58)	<.001
1	3739 (16.3)	835 (17.3)	4574 (16.5)	
2	2813 (12.3)	876 (18.1)	3689 (13.3)	
≥3	2344 (10.2)	1067 (22.1)	3411 (12.3)	
Risk factors for CRC				
Alcohol abuse	588 (2.6)	103 (2.1)	691 (2.5)	.08
Tobacco use	4752 (20.7)	1092 (22.6)	5844 (21)	.004
Overweight or obese	5016 (21.9)	847 (17.5)	5863 (21.1)	<.001
NSAID use	14 (0.1)	13 (0.3)	27 (0.1)	<.001
Family history of CRC or polyps	3303 (14.4)	514 (10.6)	3817 (13.7)	<.001

Abbreviations: CRC, colorectal cancer; NSAID, nonsteroidal anti-inflammatory drug.

likely to have CRC compared with patients with a Charlson score of 0 (HR, 1.97; 95% CI 1.42-2.73).

To examine how CRC incidence varied with age, another adjusted Cox regression analysis was performed with age categorized into 5-year age groups (50-54, 55-59, 60-64, 65-69, 70-74, and ≥75 years). The CRC incidence for the 75-year-and-older age group was significantly lower than the younger reference age group (50-54 years) (HR, 0.05; 95% CI, 0.02-0.13). All other age strata had similar CRC incidence when compared with the reference age group (age 55-59 years, HR, 0.77 [95% CI, 0.53-1.13]; age 60-64 years, HR, 0.99 [95% CI, 0.70-1.40]; age 65-69 years, HR, 1.08 [95% CI, 0.77-1.51]; and age 70-74 years, HR, 0.90 [95% CI, 0.63-1.29]).

Hospitalization After Surveillance Colonoscopy

A total of 27 628 patients were included in the analysis of postsurveillance colonoscopy hospitalizations after excluding 135 who did not meet the 30-day enrollment criterion. A total of 711 patients (2.6%) were hospitalized within 30 days of surveillance examination. Higher hospitalization rate was noted among the elderly cohort than the reference cohort (3.8% [n = 527] and 2.3% [n = 184], respectively; $P < .001$). This finding was consistent across both sexes (eTable 6 in the Supplement).

Indications for hospitalization included procedure-related complications (13.0%), gastrointestinal-related complications (33.0%), or other causes (30.1%) (eTable 1 in the Supplement). Individual breakdown of the cause for hospital-

izations are provided in eTables 2 to 4 in the Supplement. Gastrointestinal tract bleeding made up the majority of the procedure-related complications (73.9%). Of note, 23.9% of patients had missing data related to their postprocedure hospitalization, where the cause was unable to be established because the discharge summary was not available in the electronic record.

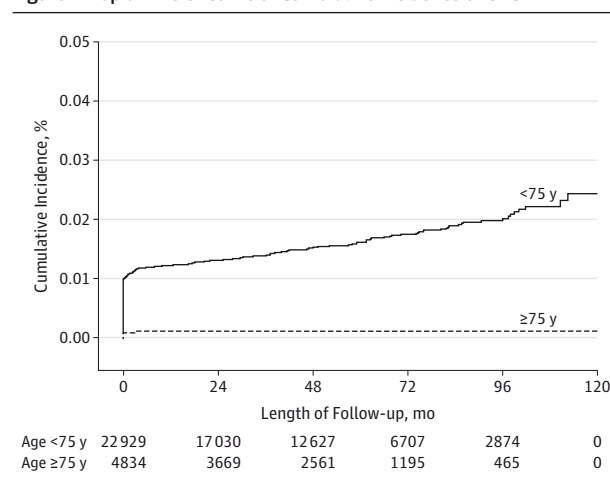
Risk Factors for Postprocedure Hospitalization: Logistic Regression

In multivariable logistic regression analysis, patients 75 years and older were at 28% higher risk of postprocedure hospitalization compared with those aged 50 to 74 years, independent of demographics and other known risk factors (OR, 1.28

[95% CI, 1.07-1.53]; $P = .006$). Charlson score of 3 or greater was independently associated with a 3-times higher risk for postprocedure hospitalization (OR, 3.75 [95% CI, 3.05-4.60]; $P < .001$) (Table 3). The analysis included adjustment for the additional variables used in Cox regression analysis.

In another similarly adjusted logistic regression, the elderly cohort was stratified into 3 age groups (75-79, 80-84, and ≥ 85 years) and compared with the younger reference cohort. The risk of hospitalization was highest in the 85-years-and-older age group. For age groups 75 to 79 years, 80 to 84 years, and 85 years and older, the ORs (95% CIs) were 1.22 (0.98-1.51) ($P = .08$); 1.34 (1.00-1.78) ($P = .048$); and 1.55 (0.99-2.43) ($P = .055$), respectively.

Figure 2. Kaplan-Meier Curve of Cumulative Incidence of CRC



Comparison between older (≥ 75 years) vs younger (< 75 years) cohorts found a statistically significant decrease in colorectal cancer (CRC) in the older cohort (log rank $P < .001$). The x-axis shows follow-up time in 24-month intervals, along with number of participants (age ≥ 75 or < 75 years) that still remained at risk (or CRC free).

Discussion

We evaluated the incidence of CRC on surveillance colonoscopy as well as the frequency of postprocedural hospitalization in a cohort of 27 763 patients with a history of either CRC or adenomatous polyps. Overall, there was a lower incidence of CRC in the elderly cohort compared with the reference population undergoing surveillance examination. By contrast, the rate of postprocedure hospitalization was substantially higher in the elderly cohort. Age 75 years and older and a Charlson score of 2 or higher were independent risk factors for postprocedure hospitalization.

Determining the potential risk and benefits of surveillance colonoscopy in the elderly population is important because the size of this segment of the population is projected to double between 2012 and 2060.⁸ Previous studies have demonstrated that increasing age can be associated with decreased physiological reserve.²⁶⁻²⁸ This may in turn potentially increase the risk of surveillance colonoscopy among the elderly population. Meanwhile, the benefits of ongoing surveillance in this population have yet to be firmly established.

Table 2. Cox Regression Analysis of CRC Incidence

Variable	Unadjusted HR (95% CI)	P Value	Adjusted HR (95% CI)	P Value
Age ≥ 75 y vs < 75 y	0.07 (0.03-0.16)	$< .001$	0.06 (0.02-0.13)	$< .001$
Female vs male	0.88 (0.72-1.09)	.24	0.91 (0.74-1.12)	.36
Asian/Pacific Islander vs white	1.40 (1.01-1.95)	.04	1.24 (0.89-1.73)	.20
Black vs white	1.18 (0.86-1.60)	.30	1.09 (0.80-1.49)	.58
Hispanic vs white	0.94 (0.69-1.29)	.71	0.86 (0.63-1.18)	.35
Other/unknown vs white	0.55 (0.33-0.93)	.03	0.52 (0.31-0.88)	.01
Charlson index				
1 vs 0	1.00 (0.73-1.36)	.98	1.09 (0.80-1.48)	.59
2 vs 0	1.91 (1.47-2.49)	$< .001$	2.19 (1.67-2.87)	$< .001$
≥ 3 vs 0	1.51 (1.12-2.05)	.008	1.97 (1.42-2.73)	$< .001$
Personal history of CRC vs polyp	1.18 (0.86-1.62)	.32	1.13 (0.81-1.57)	.48
Alcohol abuse	0.94 (0.47-1.89)	.86	0.92 (0.45-1.88)	.82
Tobacco use	0.95 (0.73-1.23)	.68	0.85 (0.64-1.11)	.23
Obese or overweight	0.80 (0.61-1.05)	.11	0.70 (0.53-0.93)	.01
Family history of CRC or polyp	0.82 (0.59-1.13)	.22	0.80 (0.58-1.11)	.19
NSAID use ^a	NA	NA	NA	NA

Abbreviations: CRC, colorectal cancer; HR, hazard ratio; NA, not applicable; NSAID, nonsteroidal anti-inflammatory drug.

^a Not determined because no cancer was detected among patients who used NSAIDs.

Table 3. Logistic Regression for Hospitalized Patients Within 30 Days of Surveillance

Parameter	Unadjusted OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
Age ≥ 75 y vs < 75 y	1.678 (1.415-1.991)	$<.001$	1.281 (1.072-1.529)	.006
Female vs male	0.932 (0.801-1.084)	.36	1.006 (0.862-1.175)	.94
Asian/Pacific Islander vs white	0.564 (0.401-0.794)	.001	0.621 (0.439-0.877)	.007
Black vs white	0.953 (0.754-1.204)	.69	0.892 (0.704-1.129)	.34
Hispanic vs white	0.964 (0.777-1.195)	.74	0.990 (0.797-1.230)	.93
Other/unknown vs white	0.428 (0.292-0.629)	$<.001$	0.541 (0.368-0.798)	.002
Charlson index				
1 vs 0	1.394 (1.102-1.763)	.006	1.345 (1.061-1.704)	.01
2 vs 0	2.686 (2.188-3.298)	$<.001$	2.541 (2.059-3.137)	$<.001$
≥ 3 vs 0	4.128 (3.423-4.978)	$<.001$	3.746 (3.051-4.601)	$<.001$
Personal history of CRC vs polyp	1.570 (1.281-1.924)	$<.001$	0.958 (0.773-1.187)	.70
Alcohol abuse	1.878 (1.307-2.700)	.001	1.579 (1.086-2.296)	.02
Tobacco use	1.548 (1.313-1.825)	$<.001$	1.117 (0.938-1.331)	.22
Obese or overweight	1.160 (0.973-1.383)	.10	0.918 (0.766-1.100)	.35
Family history of CRC or polyp	0.858 (0.683-1.078)	.19	0.875 (0.695-1.102)	.26
NSAID use	1.460 (0.198-10.752)	.71	0.658 (0.088-4.900)	.68

Abbreviations: CRC, colorectal cancer; NSAID, nonsteroidal anti-inflammatory drug; OR, odds ratio.

Prior studies evaluating incidence of CRC in the elderly population have produced inconsistent findings.

Our study demonstrated a decrease in CRC during surveillance colonoscopy with increasing age. Incidence of CRC in our elderly cohort was 10 times less than the SEER data when examining the CRC incidence rate by age (≥ 75 years) for the year 2000-2011.²⁹

In a retrospective study by Khan et al,¹¹ it was found that increasing age was associated with increased risk of malignancy. However, no specification was made whether elderly patients in this study had undergone prior colonoscopy. In a study by Duncan et al,³⁰ diagnostic yield of malignancy was low in elderly patients (average age, 83 years) undergoing screening or surveillance examination. In contrast, others have reported a high yield of CRC and polyps.^{23,31} However, these studies included a wide range of age groups and, in particular, did not distinguish between surveillance or screening examinations. Literature review on posttreatment CRC recurrence also found high rates of CRC recurrence but only followed up patients for the first 1 to 2 years after curative surgical resection.^{22,32-34} This is unlike our study that examined surveillance colonoscopies over several years.

Our study of adverse events postsurveillance colonoscopy tracked similarly to prior studies evaluating colonoscopy in general.^{9,10,13,15-17} Of particular note, in a retrospective study by Kahi et al¹⁰ that focused on persons 75 years or older, postprocedure mortality was increased among patients older than 75 years and increasing Charlson score. Another meta-analysis by Day et al⁹ found higher adverse events in older patients (≥ 80 years). This study pooled incidence rates for adverse events in patients undergoing colonoscopy. In octogenarians, adverse events (per 1000 colonoscopies) included the following: cumulative gastrointestinal adverse event rate, 34.9 (95% CI, 31.9-38.0); gastrointestinal tract bleeding rate, 2.4 (95% CI, 1.1-4.6); and mortality rate, 0.5 (95% CI, 0.06-1.9). Our data of adverse events defined as postprocedure hospitalization within 30 days found a higher hospitalization rate

among the elderly cohort compared with the younger cohort (3.8% [n = 527] and 2.3% [n = 184], respectively; $P < .001$) but included other causes of hospitalizations in addition to adverse gastrointestinal causes.

In the present study, increasing age (≥ 75 years) was associated with decreased CRC incidence on surveillance. There are several potential explanations for these findings. First, the decrease in CRC on surveillance with age may be because prior surveillance or screening was successful in removing potentially malignant lesions. Another possibility is that elderly patients may have been more likely to experience death from other comorbidities, as noted in our study and by other previous studies.^{10,12} In one study by Kahi et al,¹⁰ 41% of its elderly patients died of cardiac causes or extracolonic malignant conditions.¹⁰ Our finding of increased hospitalizations associated with increasing age and Charlson comorbidity support the underlying theory that with increasing age, the physiologic reserve for elderly patients to tolerate the surveillance examination decreases. In addition, on individual hospital record review, the major procedure-related complication was gastrointestinal tract bleeding. While procedure related complications comprised only 13% of postprocedure hospitalizations, exacerbation of underlying comorbid illness was a major indication for unplanned admissions (63.1%). While not directly related to the procedure per se, exacerbation of underlying comorbidities may be a potential indirect consequence of invasive testing in this population.

Of note, our study also found that increasing comorbidity was associated with increased CRC incidence. Previous studies have evaluated the relationship between Charlson score and age in the CRC population.³⁵⁻³⁷ These studies found higher comorbidity to be associated with increasing age. Higher comorbidity was also associated with poorer prognosis. We speculate that one reason increasing comorbidity was associated with higher CRC incidence may be attributed to a lower level of surveillance intensity, such that

patients with increasing comorbidity may undergo fewer routine surveillance examinations. In contrast, healthy patients who are older may have had more opportunities to undergo surveillance testing. Prior literature has suggested such an effect.³⁸

The present study has several strengths and limitations. Despite adjusting for multiple risk factors associated with CRC including Charlson score and age,^{10,25} there is a potential for residual confounders. The comparison with a younger reference cohort instead of an age-matched control group was performed to help reduce potential selection bias. Other limitations included coding errors and possible underestimation of postsurveillance hospitalizations, given that emergency visits were not included in our analysis. The study's strengths include its large cohort size with the use of an integrated care

system requiring 1 year longitudinal follow-up prior to procedure for accurate staging of comorbidities. An internal prospective cancer registry facilitated identification of patients diagnosed as having CRC.

Conclusions

Our study on surveillance colonoscopy found a low incidence of CRC and a high rate of postprocedure hospitalization in the elderly population (age ≥ 75 years) compared with the reference population (age 50-74 years). On the basis of these findings, we believe future recommendations for surveillance in elderly patients should be individualized, with strong consideration given to Charlson score and advanced age.

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Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: All authors.

Study supervision: Wu.

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REFERENCES

- Qaseem A, Denberg TD, Hopkins RH Jr, 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(5):378-386.
- US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2008;149(9):627-637.
- Travis AC, Pievsky D, Saltzman JR. Endoscopy in the elderly. *Am J Gastroenterol.* 2012;107(10):1495-1501.
- Lieberman DA, Rex DK, Winawer SJ, Giardiello FM, Johnson DA, Levin TR; United States Multi-Society Task Force on Colorectal Cancer. Guidelines for colonoscopy surveillance after

screening and polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology.* 2012;143(3):844-857.

5. Day LW, Walter LC, Velayos F. Colorectal cancer screening and surveillance in the elderly patient. *Am J Gastroenterol.* 2011;106(7):1197-1206.

6. Chandrasekhara V, Early DS, Acosta RD, et al; ASGE Standards of Practice Committee. Modifications in endoscopic practice for the elderly. *Gastrointest Endosc.* 2013;78(1):1-7.

7. Wilson JA. Colon cancer screening in the elderly: when do we stop? *Trans Am Clin Climatol Assoc.* 2010;121:94-103.

8. Newsroom: "US Census Bureau Projections Show a Slower Growing, older, more diverse nation a half century from now." <http://www.census.gov/newsroom/releases> Accessed January 1, 2014.

9. Day LW, Kwon A, Inadomi JM, Walter LC, Somsouk M. Adverse events in older patients undergoing colonoscopy: a systematic review and meta-analysis. *Gastrointest Endosc.* 2011;74(4):885-896.

10. Kahi CJ, Azzouz F, Juliar BE, Imperiale TF. Survival of elderly persons undergoing colonoscopy: implications for colorectal cancer screening and surveillance. *Gastrointest Endosc.* 2007;66(3):544-550.

11. Khan S, Ahmed J, Lim M, et al. Colonoscopy in the octogenarian population: diagnostic and survival outcomes from a large series of patients. *Surgeon.* 2011;9(4):195-199.

12. Kistler CE, Kirby KA, Lee D, Casadei MA, Walter LC. Long-term outcomes following positive fecal occult blood test results in older adults: benefits and burdens. *Arch Intern Med.* 2011;171(15):1344-1351.

13. Ko CW, Sonnenberg A. Comparing risks and benefits of colorectal cancer screening in elderly patients. *Gastroenterology.* 2005;129(4):1163-1170.

14. Ko CW, Riffle S, Michaels L, et al. Serious complications within 30 days of screening and surveillance colonoscopy are uncommon. *Clin Gastroenterol Hepatol.* 2010;8(2):166-173.

15. Rutter CM, Johnson E, Miglioretti DL, Mandelsohn MT, Inadomi J, Buist DS. Adverse events after screening and follow-up colonoscopy. *Cancer Causes Control.* 2012;23(2):289-296.

16. Warren JL, Klabunde CN, Mariotto AB, et al. Adverse events after outpatient colonoscopy in the

Medicare population. *Ann Intern Med.* 2009;150(12):849-857, W152.

17. Rabeneck L, Paszat LF, Hilsden RJ, et al. Bleeding and perforation after outpatient colonoscopy and their risk factors in usual clinical practice. *Gastroenterology.* 2008;135(6):1899-1906.

18. Amonkar MM, Hunt TL, Zhou Z, Jin X. Surveillance patterns and polyp recurrence following diagnosis and excision of colorectal polyps in a Medicare population. *Cancer Epidemiol Biomarkers Prev.* 2005;14(2):417-421.

19. Cottet V, Jooste V, Fournel I, Bouvier AM, Faivre J, Bonithon-Kopp C. Long-term risk of colorectal cancer after adenoma removal: a population-based cohort study. *Gut.* 2012;61(8):1180-1186.

20. Huang Y, Gong W, Su B, et al. Recurrence and surveillance of colorectal adenoma after polypectomy in a southern Chinese population. *J Gastroenterol.* 2010;45(8):838-845.

21. Laiyemo AO, Murphy G, Albert PS, et al. Postpolypectomy colonoscopy surveillance guidelines: predictive accuracy for advanced adenoma at 4 years. *Ann Intern Med.* 2008;148(6):419-426.

22. Lautenbach E, Forde KA, Neugut AI. Benefits of colonoscopic surveillance after curative resection of colorectal cancer. *Ann Surg.* 1994;220(2):206-211.

23. Lin OS, Kozarek RA, Schembre DB, et al. Screening colonoscopy in very elderly patients: prevalence of neoplasia and estimated impact on life expectancy. *JAMA.* 2006;295(20):2357-2365.

24. Miller HL, Mukherjee R, Tian J, Nagar AB. Colonoscopy surveillance after polypectomy may be extended beyond five years. *J Clin Gastroenterol.* 2010;44(8):e162-e166.

25. Manne U, Shanmugam C, Katkooi VR, Bumpers HL, Grizzle WE. Development and progression of colorectal neoplasia. *Cancer Biomark.* 2010;9(1-6):235-265.

26. Hollis S, Lecky F, Yates DW, Woodford M. The effect of pre-existing medical conditions and age on mortality after injury. *J Trauma.* 2006;61(5):1255-1260.

27. McLean AJ, Le Couteur DG. Aging biology and geriatric clinical pharmacology. *Pharmacol Rev.* 2004;56(2):163-184.

28. Fedarko NS. The biology of aging and frailty. *Clin Geriatr Med.* 2011;27(1):27-37.

29. National Cancer Institute. Age-Adjusted Rates By Data Type Colon and Rectum, Ages 75+, All Races, Both Sexes 1992-2011. <http://seer.cancer.gov/faststats/selections.php?series=data>. Accessed May 2014.
30. Duncan JE, Sweeney WB, Trudel JL, Madoff RD, Mellgren AF. Colonoscopy in the elderly: low risk, low yield in asymptomatic patients. *Dis Colon Rectum*. 2006;49(5):646-651.
31. 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(2):298-303.
32. Ji JS, Choi KY, Lee WC, et al. Endoscopic and histopathologic predictors of recurrence of colorectal adenoma on lowering the miss rate. *Korean J Intern Med*. 2009;24(3):196-202.
33. Rodríguez-Moranta F, Saló J, Arcusa A, et al. Postoperative surveillance in patients with colorectal cancer who have undergone curative resection: a prospective, multicenter, randomized, controlled trial. *J Clin Oncol*. 2006;24(3):386-393.
34. Tan KK, Koh FH, Tan YY, Liu JZ, Sim R. Long-term outcome following surgery for colorectal cancers in octogenarians: a single institution's experience of 204 patients. *J Gastrointest Surg*. 2012;16(5):1029-1036.
35. Sarfati D, Tan L, Blakely T, Pearce N. Comorbidity among patients with colon cancer in New Zealand. *N Z Med J*. 2011;124(1338):76-88.
36. Ostenfeld EB, Nørgaard M, Thomsen RW, Iversen LH, Jacobsen JB, Sogaard M. Comorbidity and survival of Danish patients with colon and rectal cancer from 2000-2011: a population-based cohort study. *Clin Epidemiol*. 2013;5(suppl 1):65-74.
37. van Leersum NJ, Janssen-Heijnen ML, Wouters MW, et al. Increasing prevalence of comorbidity in patients with colorectal cancer in the South of the Netherlands 1995-2010. *Int J Cancer*. 2013;132(9):2157-2163.
38. Foley KL, Song EY, Klepin H, Geiger A, Tooze J. Screening colonoscopy among colorectal cancer survivors insured by Medicaid. *Am J Clin Oncol*. 2012;35(3):205-211.