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Serious complications within 30 days of screening and surveillance colonoscopy are uncommon

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Abstract

Background & Aims—The risk of serious complications after colonoscopy has important implications for the overall benefits of colorectal cancer screening programs. We evaluated the incidence of serious complications within 30 days after screening or surveillance colonoscopies in diverse clinical settings and to identify potential risk factors for complications.

Methods—Patients age 40 and over undergoing colonoscopy for screening, surveillance, or evaluation based on an abnormal result from another screening test were enrolled through the National Endoscopic Database (CORI). Patients completed a standardized telephone interview approximately 7 and 30 days after their colonoscopy. We estimated the incidence of serious complications within 30 days of colonoscopy and identified risk factors associated with complications using logistic regression analyses.

Results—21,375 patients were enrolled. Gastrointestinal bleeding requiring hospitalization occurred in 34 patients (incidence 1.59/1000 exams; 95% confidence interval [CI] 1.10–2.22). Perforations occurred in 4 patients (0.19/1000 exams; 95% CI 0.05–0.48), diverticulitis requiring hospitalization in 5 patients (0.23/1000 exams; 95% CI 0.08–0.54), and post-polypectomy syndrome in 2 patients (0.09/1000 exams; 95% CI 0.02–0.30). The overall incidence of complications directly related to colonoscopy was 2.01 per 1000 exams (95% CI 1.46–2.71). Two of the four perforations

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occurred without biopsy or polypectomy. The risk of complications increased with pre-procedure warfarin use and performance of polypectomy with cautery.

Conclusions—Complications after screening or surveillance colonoscopy are uncommon. Risk factors for complications include warfarin use and polypectomy with cautery.

Background

Recent guidelines recommend screening colonoscopy for average risk patients beginning at age 50¹⁻⁶. Over 14 million colonoscopies are performed annually in the United States, approximately half for screening indications⁷. Examination of the potential adverse effects of colonoscopy is needed to understand the relative risks and benefits of screening programs. Prior studies examining complications after colonoscopy have some limitations, such as looking at complication rates in single practice settings, studying procedures done by expert endoscopists, or using administrative data⁸⁻¹⁸. Studies using administrative data may be limited in clinical detail and must rely upon accuracy of procedure and diagnosis coding. In addition, many studies have focused primarily on colonoscopic perforations, and rates of other complications such as gastrointestinal bleeding are less clear. Complication rates specific to screening or surveillance colonoscopy have been examined only in clinical studies of screening colonoscopy or in well-defined practice settings^{12, 19}.

We performed a multi-center study in diverse practice settings to better understand the risks associated with screening or surveillance colonoscopy. The aims of this study were to examine the incidence of serious complications resulting in hospitalization within 30 days after colonoscopy, and to identify risk factors associated with these events.

Methods

Setting and Participants

This prospective cohort study was performed within the Clinical Outcomes Research Initiative National Endoscopic Database (CORI), a nationwide data repository for gastrointestinal endoscopy procedures²⁰. Eighty-five centers and over 530 physicians participate in CORI. For this study, 18 CORI practices volunteered to participate, including 1 academic, 5 Veterans Administration, and 12 private practice sites. Veterans Administration sites were relatively over-represented compared to CORI sites in general. The study was approved by the Institutional Review Boards at the University of Washington, Oregon Health and Science University, Centers for Disease Control and Prevention, and local practice sites.

Practice sites participating in CORI must use specialized software to generate all procedure reports. Data including procedure indications, findings, and performance of biopsy or polypectomy, are entered into the software to generate the medical record report. Because reports are generated post-procedure, the listed indication may incorporate procedure findings, and not entirely reflect the actual colonoscopy indication. Data are also entered regarding patient demographics, comorbidity using the American Society of Anesthesiologists (ASA) classification, procedure completeness, and medications used. In addition, endoscopists are required to complete the data entry fields for immediate complications before a report can be finalized.

Patients age 40 and over undergoing colonoscopy at a participating site were eligible if their primary indication for colonoscopy was average risk colorectal cancer screening, personal history of colorectal polyps or cancer, family history of colorectal polyps or cancer, or follow-up of another abnormal screening test. Patients were excluded if they had a history of inflammatory bowel disease or recent visible gastrointestinal bleeding. Patients were eligible for only their first colonoscopy during the study period.

Study procedures

Eligible patients were identified by staff at the local practice sites or by CORI research personnel, contacted at approximately 7 and 30 days after colonoscopy, and gave oral consent to participate when contacted. Of 40,637 eligible subjects, 21,375 were enrolled (53% of eligible), and 18,271 were followed to 30 days (85% of enrolled). A standardized telephone questionnaire was administered to ascertain the occurrence of hospitalizations, the symptoms and diagnoses leading to hospital admission, and requirements for blood transfusions or unplanned surgery. We asked about use of aspirin, non-steroidal anti-inflammatory medications, warfarin, ticlopidine, or clopidogrel prior to colonoscopy. To validate subjects' self-reported diagnoses, we received permission to review 52 medical records from 9 of the 13 practice sites who reported hospitalizations. Data from these records were abstracted onto standardized forms. As the medical records review agreed with subjects' self-report in over 80% of cases, we used self-reported diagnoses for all analyses. Discordance of symptoms occurred in <10% of cases reviewed, with discordance in therapy accounting for the remainder of cases. We also queried the National Death Index to determine vital status for eligible, non-enrolled subjects and for enrolled subjects who were contacted at 7 days, but not at 30 days²¹.

Biopsy status was divided into biopsy with or without cautery, as was polypectomy status. If subjects had more than one type of biopsy or polypectomy performed, they were characterized according to the most advanced procedure performed. For example, if subjects had both biopsy without cautery and polypectomy with cautery, they were included in the "polypectomy with cautery" group.

Outcomes

We examined the incidence of serious events directly related to colonoscopy, as ascertained by subjects' self-report, including perforation, postpolypectomy syndrome, gastrointestinal bleeding requiring hospitalization and/or transfusion, and diverticulitis. The primary outcome was an aggregate measure of these four most serious complications requiring hospitalization within 30 days. We also examined the incidence of hospitalizations for other potentially related events, including angina, myocardial infarction, stroke, transient ischemic attack, and other potentially related complications such as abdominal pain or sedation-related events.

Statistical analysis

We calculated the incidence of complications per 1000 exams and 95% confidence intervals using the binomial distribution. We used forward step-wise logistic regression analysis to study the association between the incidence of complications and risk factors of interest, including age; sex; race; ethnicity; preprocedure use of warfarin, aspirin, clopidogrel, or nonsteroidal anti-inflammatory agents; biopsy or polypectomy; colonoscopy indication; trainee participation; and practice setting. Age and sex were included in all models, and any other variable with global $p < 0.1$ was retained in the final model. Analyses were performed using SPSS, version 15.0 (SPSS Inc, Chicago, IL).

Role of the funding source

This work was supported by the Centers for Disease Control and Prevention, Prevention Research Program, and by the National Institutes of Health. The Centers for Disease Control and Prevention assisted in design, conduct, and analysis of this study. The funding sources had no role in the decision to submit the manuscript for publication.

Results

We recruited 21,375 patients, and were able to contact 18,271 at the 30 day time point. Seventy-six percent of subjects were enrolled from community-based practice settings. Characteristics of enrolled subjects were similar overall to eligible but not enrolled patients, except that a slightly higher percentage of non-enrolled subjects were from community-based practices (Table 1).

Complications during colonoscopy

Using data entered into the colonoscopy report, we examined the incidence of complications at the time of colonoscopy (Table 2). The overall incidence of complications at the time of colonoscopy was 12.9/1000 exams (95% CI 11.5-14.5), most commonly respiratory depression (incidence 7.5/1000 exams, 95% CI 6.4-8.7). Immediate cardiovascular complications, most commonly hypotension or bradycardia, occurred in 4.9/1000 exams (95% CI 4.0-5.9). Complications were self-limited in the majority, but medications including atropine, flumazenil, and naloxone, were given for management of acute complications in 2.9/1000 exams (95% CI 2.2-3.7). Five patients were hospitalized immediately after colonoscopy for observation or management of complications, including abdominal pain and prolonged sedation; none of these 5 patients required blood transfusion or additional invasive procedures.

Incidence of complications within 30 days

Using data from follow-up telephone calls, we examined the incidence of complications up to 30 days after colonoscopy in all enrolled patients (Table 3). Secondary outcomes included the incidence of complications at 7 days and at 30 days only in patients followed to this time point. The overall incidence of serious complications directly related to colonoscopy in enrolled patients (including perforation, postpolypectomy syndrome, gastrointestinal bleeding, and diverticulitis) was 2.01/1000 exams (95% CI 1.46-2.71). This includes patients from table 2 who were hospitalized immediately after colonoscopy for these complications. The most common complication requiring hospitalization was gastrointestinal bleeding (incidence 1.59/1000 exams; 95% CI 1.10- 2.22), with transfusion required in 0.79/1000 exams (95% CI 0.46-1.27). Perforations occurred in 4 patients (incidence 0.19/1000 exams; 95% CI 0.05-0.48) and post-polypectomy syndrome in 2 patients (incidence 0.09/1000 exams; 95% CI 0.02-0.30). The four perforations all occurred in women with ages varying between 53 and 79. One of these patients had a snare polypectomy with cautery to remove a 20 millimeter sessile polyp, and a second patient had a snare polypectomy without cautery to remove an 8 millimeter sessile polyp. A third patient had an incomplete colonoscopy because of difficulty intubating the cecum, but did not have any biopsies or polypectomies performed. The fourth patient had a complete colonoscopy without biopsy or polypectomy.

We also examined other potentially related hospitalizations within 30 days of the index colonoscopy. Angina or myocardial infarction occurred in 0.56/1000 examinations (95% CI 0.29-0.98), with stroke or transient ischemic attack occurring in 0.33/1000 examinations (95% CI 0.13-0.67). In the follow-up telephone calls, subjects reported potentially related hospitalizations for abdominal pain (n=5), biliary colic (n=3), perirectal abscess (n=2), prolonged recovery from sedation (n=3), pneumonia (n=2), splenic hematoma (n=1), nausea and vomiting from bowel preparation (n=1), and post-procedure ileus (n=3). Combining these additional potentially related events, neurologic events, cardiovascular events, and events directly related to the colonoscopy, the incidence of serious complications directly or potentially related to the exam was 3.18/1000 exams (95% CI 2.47-4.03). In secondary analyses including only patients followed to 30 days, the incidence of complications was similar (Table 3).

Risk factors for complications

On univariate analysis, the incidence of complications increased with increased patient age and higher ASA comorbidity classification, and was higher for patients who were male, African-American (vs. white), Hispanic, had history of polyps, or had polypectomy with cautery (Table 4). No complications occurred in Asians, Pacific Islanders, Native Americans, or subjects of mixed/other/unknown race. Pre-procedure use of aspirin, warfarin or clopidogrel was also associated with complications. Higher complication rates occurred in academic and VA settings. The data on endoscopist volume and complication rates were difficult to interpret since we had a relatively small number of endoscopists.

Polyp morphology is available for 85% of the polyps in the study database. In the overall population with available data, 11% of polyps were pedunculated, while 30% were pedunculated in patients with gastrointestinal bleeding. Because some patients with gastrointestinal bleeding had multiple polyps with both pedunculated and sessile morphologies, drawing any conclusions about the relationship of polyp morphology to bleeding risk is difficult. Polyp size is available for 90% of patients in the study database. Since many patients have more than one polyp removed, it is difficult to know which size polyp may have been responsible for bleeding. However, eight of the 28 patients with postpolypectomy bleeding (28%) had only polyps <1 centimeter in size, compared to 88% in the overall study population. Because of the small number of perforations, we cannot make any firm conclusions about the relationship between polyp size or morphology and risk of perforation.

For the multivariate models, we present the analyses for serious complications within 30 days directly related to colonoscopy (gastrointestinal bleeding, perforation, postpolypectomy syndrome, and diverticulitis) and serious colonoscopy complications plus other potentially related events (as described above). Although patient age and sex were not significantly associated with the risk of complications, but we adjusted for these variables in the final models (Table 5). A statistically significant increased risk of complications was seen with use of polypectomy with cautery (OR 6.71; 95% CI 2.79-16.10 for directly-related events). Further increases in risk were found if >1 polypectomy with cautery was performed (OR 12.05; 95% CI 5.06-28.67). Biopsy (with or without cautery) and polypectomy without cautery were not statistically significantly associated with complication rates, though wide confidence intervals do not exclude a clinically important difference in risk estimate. Pre-procedure warfarin was statistically significantly associated with adverse events (OR 2.88, 95% CI 1.18-7.04 for directly related complications; OR 3.08, 95% CI 1.49-6.37 for all potentially related complications), while clopidogrel was statistically significantly associated with the combined outcome of directly and potentially related complications (OR 2.69; 95% CI 0.96-7.51).

ASA classification, use of aspirin or nonsteroidal anti-inflammatory agents, and provider-related variables including endoscopist volume were not statistically significant predictors, and were not included in the final model. Comorbidity level increased with increasing age of participant.

Deaths after colonoscopy

We queried the National Death Index to examine vital status for eligible patients who were not enrolled, and for enrolled subjects who were contacted at 7 days, but not at 30 days. This query revealed 2 deaths following colonoscopy. The first death occurred 6 days after colonoscopy in a patient with underlying liver failure undergoing routine evaluation prior to liver transplantation, likely secondary to the underlying liver failure. The second death occurred at 33 days due to aspiration pneumonia. In addition to these deaths from the National Death Index, we identified one death in an eligible patient who could not be contacted at the 7-day time point. When contacted at 30-days, the subject's family reported the death at 3 days after

colonoscopy. This death was not confirmed in the National Death Index, but was confirmed in the Social Security Death Index, and the cause of death is unknown.

Discussion

The risk of serious complications within 30 days after screening and surveillance colonoscopy was low in our study, with an incidence of perforations of 0.19/1000 exams and gastrointestinal bleeding requiring hospitalization in 1.59/1000 exams. The overall incidence of serious, directly related complications was 2.01/1000 exams, and the incidence of all directly and potentially related events was 3.18/1000 exams (Table 3). Immediate procedure-related complications were uncommon (Table 2), and aggressive intervention such as administration of reversal medications was infrequent.

Patients who underwent snare polypectomy with cautery had a significantly increased risk of serious complications. Risk increased even further if more than one polypectomy with cautery was performed. We also identified clinical characteristics associated with higher risk. Most notably, the incidence of complications was higher in patients who used warfarin prior to colonoscopy, but was not significantly associated with use of aspirin or non-steroidal anti-inflammatory agents. Data on whether warfarin was stopped before the procedure and the length of time it was withheld were missing in 40% of patients, so we could not analyze how these practices may affect complication risks. Further studies of these issues may help understand the association between colonoscopy complications and the use of this medication. In addition, warfarin use may be a surrogate marker for higher comorbidity, which was not captured well by the data about ASA classification that was available from the colonoscopy reports. Although there was a suggestion that complication rates increased with age, age was not statistically significant in the logistic model. We did not find a significant association between provider characteristics, such as practice setting, trainee participation, or endoscopists' annual colonoscopy volume, and the risk of complications. However, CORI endoscopists during the study period were fellowship-trained gastroenterologists, and we could not examine the effects of endoscopist specialty. We did not have data about years in practice or board certification to determine if these were related to complication rates.

The risk of perforation in our study is slightly lower than in other published studies^{8-10, 18, 19}. Levin, et al., found an incidence of perforation of 0.9/1000 colonoscopies, and an incidence of gastrointestinal bleeding of 3.2/1000 colonoscopies¹⁹. In this study, the risk of perforation or bleeding in colonoscopies with biopsy or polypectomy was similar to ours. Our lower overall risk of complications may be due to a lower proportion of colonoscopies with biopsy or polypectomy. Rabeneck, et al., also identified polypectomy as a risk factor for complications¹⁸. In contrast to our study, having a colonoscopy performed by a low-volume endoscopist was a predictor of complications. We did not find a statistically significant association between colonoscopy volume and complication risk, but the small number of colonoscopies performed by low-volume providers in our study limited our ability to address this question. Finally, Warren, et al., using Medicare claims data, found a perforation rate of 0.7/1000 exams, and also found an association of complications with use of biopsy or polypectomy, and with increasing age and comorbidity¹⁷. Their perforation rates may be slightly higher than ours because they included a larger proportion of older patients, and included exams done for both diagnostic and screening indications.

We used data from the American Heart Association to calculate expected rates of myocardial infarction and stroke in a population with comparable age, sex, and racial distribution²². The expected annual adjusted rate of myocardial infarction is 5.0 per 1000, or 0.49 per 1000 over 30 days, comparable to the rates we found here. The expected annual adjusted rate of stroke is

4.9 per 1000, or 0.48 per 1000 over 30 days, again comparable to our results. These findings are similar to those of Warren, et al ¹⁷.

This study has several strengths. First, unlike most prior studies, we focused primarily on screening and surveillance colonoscopy. This is a large study with follow-up until 30 days post-colonoscopy. Data were collected prospectively in diverse practice settings, with a majority of patients enrolled from community-based practices where most colonoscopies are performed. Because we had access to the CORI data repository, we had detailed information about the colonoscopy itself, including procedure indications and type of biopsy or polypectomy performed. We collected data about pre-procedure use of aspirin, non-steroidal anti-inflammatory agents, warfarin, and clopidogrel to examine the influence of these medications on complication risk.

Our study has some limitations. First, our overall enrollment rate was 53%, potentially biasing our estimates of complication rates. However, the demographic and clinical characteristics of enrolled and non-enrolled patients were generally similar. It is difficult to know the potential magnitude and direction of bias introduced by our enrollment rate. Non-enrollment may be associated with better outcomes as unenrolled patients without adverse events may have declined to participate. Conversely, it is also possible that we could not contact patients with poor outcomes, so that non-enrollment was selectively biased towards patients who had experienced complications. To examine the possibility that subjects were not enrolled because they had experienced a serious colonoscopy complication, we queried the National Death Index to identify potential deaths in non-enrolled patients, and did not find any deaths that could be definitively linked to the colonoscopy. As mentioned above, we did identify one death in a non-enrolled subject when the subject's family member was contacted at 30 days. Because we could not follow all enrolled subjects to 30 days, we may have under-estimated complication rates. However, the estimated incidence of complications was similar in all enrolled patients and in secondary analyses including only patients with complete follow-up. In the CORI software, there are not standardized definitions for immediate complications such as hypotension or bradycardia. However, endoscopists are asked about the occurrence of unplanned events or the need for unplanned interventions. By ascertaining events in this manner, the colonoscopy reports are likely to capture events that the endoscopist considers clinically significant. In order to ensure adequate ascertainment of these events, endoscopists are required to complete the data entry fields for immediate complications before a colonoscopy report can be finalized.

We did not have detailed information on specific comorbidities but rather used the ASA classification as a general measure of comorbidity. Thus, we could not determine which individual comorbid conditions were associated with complication rates. Finally, CORI endoscopists are generally fellowship-trained gastroenterologists who may differ in important ways from endoscopists who do not participate in CORI, such as having greater interest or expertise in endoscopy. Participating endoscopists may therefore experience different complication rates from endoscopists in general, potentially affecting the generalizability of our results. Nevertheless, our study examined procedures performed in diverse community practice settings as well as academic and VA settings.

In conclusion, colonoscopy is a key colorectal cancer screening modality, but may be associated with higher complication rates than other less invasive screening modalities. We found that complications from screening and surveillance colonoscopy are uncommon, with serious complications directly related to the colonoscopy occurring in approximately 2 of 1000 exams. The overall rate of hospitalizations within 30 days for directly and potentially related events was 3.18/1000 exams. We identified some characteristics associated with higher complication rates, including polypectomy with cautery and pre-procedure warfarin or

clopidogrel use. These results may help inform patients, physicians, and policy makers in examining the different options for colorectal cancer screening.

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Table 1

Baseline demographic characteristics of enrolled subjects and eligible patients who did not enroll

	Enrolled, % N=21,375	Eligible, not enrolled, % N=19,262
Age (years)		
40-49	5.7	9.1
50-59	37.5	40.7
60-69	31.2	29.0
70-79	20.2	17.0
80+	5.4	4.2
Sex		
Male	55.0	56.1
Female	45.0	43.9
Race		
White	90.3	88.8
African-American	7.6	7.6
Asian	1.3	3.8
Native American	0.5	0.5
Pacific Islander	0.1	0.1
Other/mixed/unknown	0.3	0.2
Ethnicity		
Not Hispanic	98.7	98.3
Hispanic	1.3	1.7
Practice type		
Community	76.4	83.3
Academic	9.1	4.1
VA	14.5	12.6
American Society of Anesthesiologists Classification		
I	25.3	25.0
II	70.6	71.3
III	4.1	3.7
Indication		
Average risk screening	41.9	39.8
Personal history of polyps or cancer	27.4	26.3
Family history of polyps or cancer	16.5	17.3
Positive screening test	14.2	16.6
Medications given		
Midazolam	92.6	98.3
Fentanyl	54.1	51.6
Meperidine	30.1	45.7
Propofol	1.4	1.3
General anesthesia	0.04	0.02

	Enrolled, % N=21,375	Eligible, not enrolled, % N=19,262
Depth of endoscope insertion		
Cecum/terminal ileum	97.8	96.4
Distal to cecum	2.2	3.6
Any polyps found		
Yes	44.1	42.1
No	55.9	57.9
Most advanced procedure done		
None	57.1	62.2
Biopsy without cautery	8.6	9.8
Biopsy with cautery	7.1	4.5
Polypectomy without cautery	4.6	2.7
Polypectomy with cautery	14.1	13.0
>1 polypectomy with cautery	8.5	7.9

Table 2

Number of patients with complications* and treatment or intervention for complications at the time of colonoscopy

	Number of Complications	Incidence per 1000 exams	95% Confidence Interval
All immediate complications	276	12.9	11.5, 14.5
Respiratory depression	160	7.5	6.4, 8.7
Any cardiovascular complications	105	4.9	4.0, 5.9
Hypotension	65	3.0	2.3, 3.9
Bradycardia	32	1.5	1.0, 2.1
Vasovagal reaction	14	0.6	0.4, 1.1
Tachycardia	2	0.1	0.01, 0.3
Hypertension	1	0.1	0.01, 0.3
Gastrointestinal bleeding	14	0.6	0.4, 1.1
Other gastrointestinal complications	12	0.6	0.3, 0.9
Nausea/vomiting	6	0.3	0.1, 0.6
Abdominal pain	6	0.3	0.1, 0.6
Medications given to treat complications			
Any	62	2.9	2.2, 3.7
Naloxone	29	1.3	0.9, 1.9
Atropine	20	0.9	0.6, 1.4
Flumazenil	16	0.7	0.4, 1.2
Hospitalization	5	0.2	0.1, 0.5
Other interventions			
Supplemental oxygen	134	6.3	5.2, 7.4
Intravenous fluids	48	2.2	1.6, 3.0

* Patient may have had >1 complication

Table 3

Incidence of serious complications within 7 and 30 days of colonoscopy

	All enrolled patients, within 30 days N=21,375		All enrolled patients, within 7 days [*] N=21,375		Patients with complete follow-up only, within 30 days [†] N=18,271	
	n	Incidence per 1000 exams (95% CI)	n	Incidence per 1000 exams (95% CI)	n	Incidence per 1000 exams (95% CI)
Complications directly related to colonoscopy[‡]	43	2.01 (1.46, 2.71)	38	1.78 (1.28, 2.41)	36	1.97 (1.40, 2.69)
Gastrointestinal bleeding requiring hospitalization	34	1.59 (1.10, 2.22)	29	1.36 (0.93, 1.92)	28	1.53 (1.04, 2.18)
Gastrointestinal bleeding requiring transfusion	17	0.79 (0.46, 1.27)	13	0.61 (0.34, 1.01)	15	0.82 (0.48, 1.32)
Diverticulitis with or without hospitalization	18	0.84 (0.50, 1.33)	12	0.56 (0.30, 0.95)	17	0.93 (0.57, 1.46)
Diverticulitis requiring hospitalization	5	0.23 (0.08, 0.54)	4	0.19 (0.06, 0.45)	5	0.27 (0.10, 0.60)
Perforation	4	0.19 (0.05, 0.48)	4	0.19 (0.06, 0.45)	3	0.16 (0.04, 0.44)
Post-polypectomy syndrome	2	0.09 (0.02, 0.30)	2	0.09 (0.02, 0.30)	2	0.11 (0.02, 0.39)
Complications potentially related to colonoscopy[§]	28	1.31 (0.87, 1.89)	15	0.7 (0.4, 1.1)	25	1.4 (0.9, 2.0)
Angina or myocardial infarction	12	0.56 (0.29, 0.98)	7	0.33 (0.14, 0.64)	12	0.66 (0.36, 1.11)
Stroke or transient ischemic attack	7	0.33 (0.13, 0.67)	6	0.28 (0.11, 0.58)	7	0.38 (0.17, 0.75)
Complications directly or potentially related to colonoscopy	68	3.18 (2.47, 4.03)	53	2.48 (1.88, 3.22)	61	3.34 (2.58, 4.26)
All hospitalizations for complications directly [‡] and potentially [§] related						

All enrolled patients, within 30 days N=21,375		All enrolled patients, within 7 days* N=21,375		Patients with complete follow-up only, within 30 days† N=18,271	
n	Incidence per 1000 exams (95% CI)	n	Incidence per 1000 exams (95% CI)	n	Incidence per 1000 exams (95% CI)
to colonoscopy					

* Includes complications at the time of colonoscopy that required hospitalization and hospitalizations up to 7 days after colonoscopy

† Includes all complications up to 30 days after colonoscopy. Subjects followed to 7 days, but not to 30 days, were not included in this secondary analysis. Patients may have experienced >1 complication.

‡ Includes perforation, gastrointestinal bleeding, postpolypectomy syndrome, and diverticulitis.

§ Includes cardiovascular events (myocardial infarction or angina pectoris), neurologic events (stroke or transient ischemic attack), abdominal pain, biliary colic, perirectal abscess, prolonged recovery from sedation, pneumonia, splenic hematoma, nausea and vomiting from bowel preparation, and ileus.

Incidence of complications within 30 days of colonoscopy according to selected patient and endoscopist characteristics

Table 4

	N	n	Complications directly related to colonoscopy*		Complications directly and potentially related to colonoscopy*	
			Incidence per 1000 exams (95% CI)		Incidence per 1000 exams (95% CI)	
Age (years)						
40-59	9234	11		1.19 (0.59, 2.13)	18	1.95 (1.16, 3.08)
60-69	6676	12		1.80 (0.93, 3.14)	21	3.14 (1.95, 4.80)
70-79	4318	15		3.48 (1.94, 5.72)	23	5.32 (3.38, 7.98)
80+	1147	5		4.36 (1.41, 10.14)	6	5.23 (1.92, 11.35)
Sex						
Male	11763	27		2.23 (1.51, 3.34)	43	3.66 (2.65, 4.92)
Female	9612	16		1.66 (0.95, 2.70)	25	2.60 (1.68, 3.84)
Race						
White	19301	38		1.97 (1.39, 2.70)	60	4.51 (3.44, 5.80)
African-American	1617	5		3.09 (1.00, 7.20)	7	4.33 (1.74, 8.90)
Ethnicity						
Not Hispanic	21080	42		1.99 (1.44, 2.69)	66	3.13 (2.42, 3.98)
Hispanic	269	1		3.72 (0.09, 20.54)	2	7.43 (0.90, 2.66)
ASA comorbidity classification						
I	5197	8		1.54 (0.66, 3.03)	13	2.50 (1.33, 4.27)
II	14529	29		2.00 (1.34, 2.86)	47	3.23 (2.38, 4.30)
III	842	6		7.13 (2.62, 15.44)	8	9.50 (4.11, 18.63)
Indication						
Average risk screening	8949	14		1.56 (0.86, 2.62)	22	2.46 (1.54, 3.72)
Personal history of polyps or cancer	5849	19		3.25 (1.96, 5.09)	25	4.27 (2.77, 6.30)
Family history of polyps or cancer	3537	5		1.41 (0.46, 3.29)	10	2.83 (1.36, 4.19)
Positive screening test	3040	5		1.64 (0.53, 3.83)	11	3.62 (1.81, 6.46)
Any polyps found						
Yes	9435	36		3.81 (2.67, 5.28)	44	4.66 (3.39, 6.36)
No	11940	7		0.58 (0.24, 1.21)	24	2.01 (1.29, 2.98)

	Complications directly related to colonoscopy*		Complications directly and potentially related to colonoscopy*	
	N	n	Incidence per 1000 exams (95% CI)	Incidence per 1000 exams (95% CI)
Most advanced procedure done				
None	12198	8	0.66 (0.28, 1.29)	2.13 (1.39, 3.12)
Biopsy without cautery	1847	0	0 (0, 1.99)	0.54 (0.01, 3.01)
Biopsy with cautery	1518	3	1.98 (0.41, 5.76)	1.98 (0.41, 5.76)
Polypectomy without cautery	978	2	2.04 (2.48, 7.37)	3.07 (0.63, 8.94)
Polypectomy with cautery	3009	14	4.65 (2.55, 7.79)	5.65 (3.29, 9.03)
>1 polypectomy with cautery	1825	16	8.76 (5.02, 14.20)	9.87 (5.86, 15.54)
Non-steroid anti-inflammatory agents				
No	20546	42	2.04 (1.47, 2.76)	3.16 (2.44, 4.03)
Yes	829	1	1.21 (0.03, 6.70)	3.62 (0.75, 10.54)
Aspirin				
No	12635	20	1.58 (0.97, 2.44)	2.61 (1.80, 3.67)
Yes	8740	23	2.63 (1.67, 3.95)	4.00 (2.79, 5.56)
Warfarin				
No	20619	37	1.79 (1.27, 2.47)	2.86 (2.18, 3.69)
Yes	756	6	7.93 (2.92, 17.19)	11.90 (5.46, 22.48)
Clopidogrel				
No	20981	41	1.95 (1.40, 2.65)	3.05 (2.35, 3.89)
Yes	394	2	5.08 (0.61, 18.21)	10.15 (2.78, 25.79)
Practice type				
Community	16336	31	1.90 (1.29, 2.69)	2.88 (2.11, 3.82)
Academic	1944	5	2.57 (0.84, 5.99)	4.63 (2.12, 8.77)
VA	3095	7	2.26 (0.91, 4.65)	3.89 (2.00, 6.76)
Endoscopist annual colonoscopy volume				
<300	3800	9	2.37 (1.08, 4.49)	4.74 (2.81, 7.48)
300-499	3287	6	1.82 (0.67, 3.97)	3.34 (1.67, 5.98)
500-699	6097	13	2.13 (1.14, 3.64)	2.78 (1.62, 4.46)
700-899	3270	5	1.53 (0.50, 3.56)	2.14 (0.86, 4.41)

	N	n	Complications directly related to colonoscopy*		Complications directly and potentially related to colonoscopy*	
			Incidence per 1000 exams (95% CI)	n	Incidence per 1000 exams (95% CI)	n
900-1099	885	0	0 (0, 4.16)	2	2.26 (0.27, 8.14)	
≥1100	3827	10	2.61 (1.25, 4.80)	13	3.39 (1.81, 5.80)	
Trainee participation in procedure						
No	19235	40	2.08 (1.49, 2.83)	62	3.22 (2.47, 4.13)	
Yes	2140	3	1.40 (0.29, 4.10)	6	2.80 (1.03, 6.09)	

* As defined in table 3.

Table 5

Logistic regression analysis of risk factors for complications within 30 days after colonoscopy

Variables included in the final model [†]	Type of Complication			
	Complications directly related to colonoscopy*		Complications directly and potentially related to colonoscopy*	
	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Age		0.18		0.14
40-59 years (reference category)	1.00		1.00	
60-69 years	1.19 (0.52, 2.72)		1.36 (0.82, 2.57)	
70-79 years	2.07 (0.93, 4.57)		2.05 (1.09, 3.86)	
≥ 80 years	2.45 (0.83, 7.22)		1.92 (0.75, 4.94)	
Sex		0.82		0.27
Female (reference category)	1.00		1.00	
Male	1.08 (0.57, 2.03)		0.93 (0.56, 1.54)	
Biopsy or polypectomy status		<0.001		<0.001
None (reference category)	1.00		1.00	
Biopsy with/without cautery	1.35 (0.36, 5.11)		0.55 (0.19, 1.58)	
Polypectomy without cautery	2.91 (0.61, 13.78)		1.31 (0.39, 4.35)	
Polypectomy with cautery	6.71 (2.79, 16.10)		2.45 (1.32, 4.55)	
>1 polypectomy with cautery	12.05 (5.06, 28.67)		3.97 (2.14, 7.38)	
Pre-procedure warfarin use		0.02		0.002
No (reference category)	1.00		1.00	
Yes	2.88 (1.18, 7.04)		3.08 (1.49, 6.37)	
Pre-procedure clopidogrel use		[‡]		0.05
No (reference category)			1.00	
Yes			2.69 (0.96, 7.51)	

* As defined in table 3.

[†] Age, sex, and other variables which were statistically significant at 0.10 level were kept in the model.[‡] Variable not statistically significant in this model