ORIGINAL ARTICLE

Complication Rates in Colonoscopy Screening for Cancer

A Prospective Cohort Study of Complications Arising During the Procedure and in the Ensuing Four Weeks

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SUMMARY

Background: Screening colonoscopy has been offered in Germany since 2002. Complications during colonoscopy were reported to be rare, but data on potential complications after colonoscopy are sparse. We aimed to comprehensively assess the frequency of complications arising during or within four weeks of screening colonoscopy.

Methods: Residents of the German federal state of Saarland without a history of colorectal cancer and without previous polypectomy who underwent a screening colonoscopy between 2010 and 2013 were included. A follow-up was conducted three months after the screening colonoscopy, including participant questionnaires and subsequent validation of self-reported complications arising during or within four weeks of screening colonoscopy, by reviewing colonoscopy records and contacting the treating physicians. A comprehensive mortality follow-up was conducted for non-responders.

Results: We recruited a total of 5527 participants from 26 practices (median age 61 years, 52% women). 5252 (95%) fully completed the questionnaire on complications and met the inclusion criteria for analysis. Among these participants, 16 cases of physician-confirmed bleeding (0.30%) and four cases of physician-confirmed perforation (0.08%) occurred during or within four weeks of colonoscopy. According to consistent reports from patients and physicians, bleeding and perforation led to hospitalization in 5 (0.095%) and 2 (0.04%) cases, respectively. Three participants died within three months of colonoscopy. In none of these cases was the cause of death related to colonoscopy.

Conclusion: We found the risk of complications of screening colonoscopy to be low, even when taking into account a potential delay of up to four weeks.

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Colorectal cancer (CRC) is the third most common cancer worldwide and the fourth most common cause of cancer death in men and women (1). Randomized controlled trials (RCTs) have demonstrated the effectiveness of flexible sigmoidoscopy in reducing both incidence of and mortality from CRC (2–5). Results from RCTs on the effectiveness of screening colonoscopy are not available yet. However, observational studies indicate even larger effects of colonoscopy and suggest that the majority of CRC cases and deaths could be prevented by screening colonoscopy with the detection and removal of precancerous lesions (6). However, potential complications, such as perforation and bleeding, are of concern in the application of colonoscopy as a primary screening method. The frequency of complications of screening colonoscopies has been assessed in a number of studies (7–17) (*eTable*). Most of these studies were conducted in the United States and in specialized centers, whereas data from population-wide screening programs from other countries are sparse.

In Germany, screening colonoscopy was introduced in October 2002 and is covered by statutory health insurance. At the same time, a national screening colonoscopy registry was implemented for monitoring (17). Routine documentation also includes the occurrence of complications. However, the documentation is restricted to complications occurring directly after the examination, possibly leading to under-reporting of complications with delayed onset. A previous study from Germany analyzing nationwide data from 2 821 392 documented screening colonoscopies found an overall complication rate of 2.8/1000 colonoscopies (17). This frequency is lower than frequencies reported in other studies that also considered only complications occurring directly after screening colonoscopy (10–12). Another study from Germany conducted an audit with 18-month follow-up among 12 134 men and women who underwent screening colonoscopy in one of 19 participating private practices in Berlin (overall complication rate: 0.46%) (18). Stock et al. investigated the risk of serious complications requiring hospitalization within 30 days of colonoscopy using routine screening data from Germany (19). The incidence of

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FIGURE

Flow-chart of the study population. KolosSal sub-study on complications of screening colonoscopy, Saarland, Germany, 2010–2013.

*Causes of death according to death certificates: unspecified chronic ischemic heart disease, pancreatic cancer, and carcinoma not otherwise specified

hospitalizations due to perforation and bleeding was 0.08% and 0.05%, respectively.

The aim of this study was to comprehensively assess the frequency of complications arising during or within four weeks of colonoscopies performed as part of the German screening colonoscopy program.

Methods

Study design and study population

Patients undergoing screening colonoscopy were recruited in the KolosSal study (“Effektivität der Früherkennungs-Koloskopie: Eine Saarland-weite Studie”), a statewide prospective cohort study in the German federal state of Saarland (approximately 1.02 million inhabitants in 2010). The primary aim of KolosSal is to assess the incidence of and mortality from colorectal cancer among participants of the German screening colonoscopy program, who were recruited between 2005 and 2013 and followed up for up to 15 years. The inclusion criteria were patients’ ability

to participate in the study, adequate knowledge of the German language, and written informed consent. Individuals with a history of colorectal cancer or previous polypectomy were excluded. There was no upper age limit. Further details on our study design have been reported elsewhere (20–23). The study was approved by the ethics committees of Heidelberg University’s Medical Department and the Saarland State Medical Association.

An ancillary study focusing on discomfort and complications arising during or within four weeks of screening colonoscopy was conducted among 5527 KolosSal participants recruited between 2010 and 2013. The present analysis focuses on the frequency of complications—in particular, the frequencies of bleeding and perforation—arising during or within four weeks of colonoscopy (no complications due to premedication were reported). Among non-responders, we also evaluated mortality rates and causes of death for any fatalities occurring within three months of screening colonoscopy.

TABLE 1

Complications arising during or within four weeks after screening colonoscopy. Self-reports by participants (N = 5252)

Complication	During screening colonoscopy n (%)	Within four weeks after screening colonoscopy n (%)	Total N (%)
Bleeding	9 (0.17)	28 (0.53)	35 (0.67)
Perforation	3 (0.06)	6 (0.11)	8 (0.15)
Total	12 (0.23)	34 (0.65)	43 (0.82)

TABLE 2

Complications during screening colonoscopy. Self-reports by participants vs. reports by treating physicians (N = 5252)

	Complications at colonoscopy reported by			
	Participant n (%)	Physician n (%)	Both, participant and physician n (%)	Either participant or physician N (%)
Bleeding	9 (0.17)	10 (0.19)	0	19 (0.36)
Perforation	3 (0.06)	2 (0.04)	1 (0.02)	4 (0.08)
Total	12 (0.23)	12 (0.23)	1 (0.02)	23 (0.44)

Data collection

In Germany, screening colonoscopy is almost exclusively performed in the outpatient setting. Study participants were recruited from 26 medical practices in Saarland certified to perform screening colonoscopy. Baseline assessment included a short patient questionnaire handed out before screening colonoscopy, focusing on personal information (age, sex, height, weight, nationality, and school education level), information on health check-ups, medication, lifestyle factors, and own and family medical history. In addition, participants' colonoscopy records were obtained and reviewed.

For the ancillary study, the treating physicians were asked to fill in a short questionnaire specifically asking about any complications occurring during screening colonoscopy, and participants were re-contacted three months after their screening colonoscopy and asked to fill in a short questionnaire on any discomfort or complication that occurred before, during, or within four weeks after the examination. Self-reported complications during and within four weeks of colonoscopy were subsequently validated by contacting participants' treating physicians.

For participants who did not return questionnaires despite two mailed reminders, information on their vital status was obtained from population registries and, if deceased, the cause of death was requested from the local public health authorities.

Statistical analysis

Descriptive data on the study population and occurrence of complications are presented in absolute and

relative frequencies. The number of deaths within three months after screening colonoscopy was then compared to the number of deaths that would have been expected for the general population of Saarland in the same time period (24) (standardized mortality ratio). Statistical significance was set at $p < 0.05$ in two-tailed testing. Analyses were performed using the statistics software SAS, version 9.4 (SAS Institute Inc., Cary, N.C., USA).

Results

Overall, 5527 participants recruited between 2010 and 2013 were contacted for the ancillary study three months after their screening colonoscopy (*Figure*). Of those, 5252 participants (95%) completed the questionnaire on complications and met the inclusion criteria for analysis. The participants' median age was 61 years; 52% were women. Non-participants in the follow-up were on average slightly younger (median, 60 years) and this group included a larger proportion of men (57%).

A total of 12 participants (0.23%) reported to have experienced complications defined as bleeding or perforation during screening colonoscopy (bleeding: $n = 9$; perforation: $n = 3$); 34 patients (0.65%) reported to have experienced such complications within four weeks after the procedure (bleeding: $n = 28$; perforation: $n = 6$) (*Figure, Table 1*). Bleeding and perforation were reported by 35 (0.67%) and 8 (0.15%) participants, respectively.

The frequencies of bleeding and perforation during colonoscopy reported by the colonoscopists were

TABLE 3

Frequency of doctor visits and hospitalization due to complications within four weeks after screening colonoscopy (N = 5252)

	Reported by participant	Self-report confirmed by treating physician*
	n (%)	n (%)
Doctor visits		
Due to bleeding	5 (0.095)	1 (0.02)
Due to perforation	3 (0.06)	0
Hospitalization		
Due to bleeding	7 (0.13)	5 (0.095)
Due to perforation	2 (0.04)	2 (0.04)

* Answers of treating physicians were available for all self-reports of participants

TABLE 4

Physician-confirmed complications arising during colonoscopy and within four weeks after colonoscopy

	At colonoscopy, according to treating physician	Within 4 weeks, medically confirmed	Total
	n (%)	n (%)	n (%)
Bleeding	10 (0.19)	6 (0.11)	6 (0.11)
Perforation	2 (0.04)	2 (0.04)	2 (0.04)
Total	12 (0.23)	8 (0.15)	8 (0.15)

comparable to those reported by the participants (bleeding: n = 10 [0.19%]; perforation: n = 2 [0.04%]) (Table 2). However, the overlap between self-reported and physician-reported complications was very small, with only one perforation being reported by both the patient and the physician. A closer look at the colonoscopy records revealed that the use of clips for the purpose of halting or preventing bleeding was documented in the colonoscopy records of three and one patients with self-reported bleeding, respectively, but these did not seem to have been rated as complications and reported as such by the physicians. Among the 10 patients with bleeding rated as a complication by the physicians, the use of clips was specifically mentioned in the colonoscopy records in five cases.

Of the 34 patients reporting complications within four weeks after colonoscopy, 8 patients (0.15%) reported having consulted a doctor and 9 patients (0.17%) reported being hospitalized due to these complications (Figure, Table 3). Feedback of treating physicians was requested for all self-reports from participants. Bleeding events and perforations were confirmed by the treating physicians in only one in five cases and in none of three cases, respectively, in which these complications were reported by patients to have

prompted them to consult a doctor. By contrast, self-reported hospitalizations due to a bleeding event was confirmed by the treating hospitals in 5 of 7 cases, and in both of 2 cases where patients reported perforation as a complication leading to hospitalization.

Combining the data shown in Tables 2 and 3, 20 physician-confirmed complications (0.38%) during (n = 12, 0.23%) or within four weeks after colonoscopy (n = 8, 0.15%) were recorded in total (Table 4). These included 16 bleedings (0.30%) and 4 perforations (0.08%).

As shown in Table 5, the 20 physician-confirmed bleedings and perforations exclusively occurred in participants with neoplasms (18/20) or other polyps (2/20), whereof 13 (65%) had advanced neoplasms (CRC or advanced adenomas). By contrast, this proportion was only 12% among participants with no complications. Other characteristics were similar between both groups. These patterns suggest that most complications were due to polypectomy rather than colonoscopy itself.

Vital status and, for deceased participants, the cause of death could be determined for 274 of the 275 participants (99.6%) who did not respond to the follow-up questionnaire. One participant could not be traced, as no matching records could be identified in the population registries. Of the 274 non-responders to the follow-up questionnaire, 3 (1.1%) had died within three months after screening colonoscopy. The number of deaths within three months after screening colonoscopy was substantially lower than the number of deaths that would have been expected according to life tables for the general population of the state of Saarland (n = 19.4, standardized mortality ratio: 3/19.4 = 0.15, 95% CI 0.039–0.421, p < 0.0001). Furthermore, in none of the deaths was there any evidence for an association between the cause of death and screening colonoscopy (Figure).

Discussion

In this statewide study from Saarland, Germany, comprehensive efforts were made to ascertain that all bleedings and perforations were captured that occurred during or within four weeks after screening colonoscopy, as well as any deaths among non-responders within three months after colonoscopy. Complications (bleeding or perforation) were reported by 43 participants (0.82%). However, except for 7 out of 9 self-reported hospitalizations due to complications, only a minority of self-reported complications were medically confirmed. On the other hand, the majority of participants with physician-reported bleedings were unaware of having experienced such a complication. This may be due to a lack of a consistent definition of what is understood by “bleeding” as a complication. In addition, it is unclear how bleeding arising after the application of clips for the prevention of bleeding should be classified and documented by the treating physician. From the patient’s perspective, bleeding appears to be generally classified as a complication, regardless of whether or not clips were used. Overall, 10

TABLE 5

Characteristics of participants with physician-confirmed complications arising during colonoscopy or within four weeks after colonoscopy vs. participants with no complications

Characteristics	Participants with confirmed complications n = 20	Participants with no complications n = 5232	P value
Sex			
– Male	12 (60%)	2512 (48%)	0.37* ¹
– Female	8 (40%)	2720 (52%)	
Age			
– Median (IQR)	65.5 (58.5–70.5)	61 (57–68)	0.23* ²
BMI			
– Median (IQR)	26.9 (24.7–29.8)	26.7 (24.1–29.7)	0.87* ²
Co-medication			
Pain medication/antirheumatic drugs			
– No	8 (40%)	1709 (33%)	0.47* ¹
– Yes	11 (55%)	3408 (65%)	
– Missing information	1 (5%)	115 (2%)	
Acetylsalicylic acid for blood thinning			
– No	15 (75%)	3737 (71%)	1.00* ¹
– Yes	5 (25%)	1402 (27%)	
– Missing information	0	93 (2%)	
Most advanced finding at screening colonoscopy			
– CRC	1 (5%)	53 (1%)	<0.0001* ¹
– Advanced adenoma	12 (60%)	556 (11%)	
– Non-advanced adenoma	5 (25%)	993 (19%)	
– Hyperplastic polyp	1 (5%)	489 (9%)	
– Histological classification of polyp unknown	1 (5%)	159 (3%)	
– No findings	0	2 982 (57%)	

*¹ Calculated using Fisher's exact test

*² Calculated using the Mann-Whitney U-test

IQR, interquartile range; CRC, colorectal cancer

physician-confirmed bleeding events and 2 perforations occurred during colonoscopy, and six bleedings and two perforations occurred within four weeks after colonoscopy, resulting in an overall rate of physician-confirmed complications of $20/5252 = 0.38\%$. Complications were almost exclusively confined to participants in whom neoplasms were detected and removed.

The frequencies of physician-confirmed bleeding and perforations during screening colonoscopy found in our study (0.19% and 0.04%, respectively) are in line with those reported in a previous study with 55 993 participants of the screening colonoscopy program in Bavaria in 2006 (0.24% and 0.04%, respectively) (12) and with those reported in 2 821 392 notifications about screening colonoscopies to the German national screening colonoscopy registry in 2003–2008 (0.15% and 0.02%, respectively) (17). In the latter analysis,

less than 1 out of 5 bleedings had been rated as “significant” by the treating colonoscopists.

However, none of these large-scale, registry-based studies included complications occurring within weeks or months after colonoscopy. Thus far, there is only one study that conducted an audit with a follow-up period of 18-months among 12 134 participants who underwent screening colonoscopy in 19 private practices in Berlin, Germany (18). In this study, the overall complication rate was 0.46%, approximately three times as high as the complication rate documented in the screening colonoscopy registry. In our study, 8 out of 20 physician-confirmed complications, including 2 out of 4 perforations, occurred within the four weeks following colonoscopy.

This finding underlines the need to include delayed complications when estimating overall complication rates of screening colonoscopy. Another registry-based

study from Germany including 269 144 screening colonoscopies also investigated bleeding events and perforations that were reported to the treating colonoscopists after the examination (13). The overall frequencies of reported bleedings and perforations were lower in this study compared to our study (0.16% and 0.02%, respectively), but due to the lack of a systematic follow-up of the participants, complications that were not brought to the physicians' attention might have been missed. Another German study estimated the risk of serious complications requiring hospitalization within 30 days of screening colonoscopy, using routine care data (19). The reported incidences were similar to our study (perforations 0.08%, bleeding 0.05%). Studies from other countries reporting on complications during or within weeks after colonoscopy strongly differed with regard to the time windows and comprehensiveness of the ascertainment of complications (7–11, 14, 15, 16) (*eTable*). Most of them showed slightly lower overall frequencies of bleeding and perforations.

To our knowledge, ours is the first study to systematically ascertain complications and deaths among non-responders during the three months following screening colonoscopy. Given that people would typically not undergo screening colonoscopy in a situation where they already have a diagnosis of a life threatening disease and that participants of screening colonoscopy may be rather health-conscious in general, the finding of substantially lower mortality in this group compared to the general population was not unexpected. Even so, it is reassuring that the causes of death were unrelated to screening colonoscopy in each of the three cases where non-responders had died within three months after the examination.

Our study has specific strengths and limitations. The strengths of this study include the large number of participants and the systematic data collection on complications during and after screening colonoscopy. For the first time it was possible to ascertain and validate complications over a time period of four weeks after screening colonoscopy. In all 5252 cases, colonoscopy records as well as medical records for validation were available for comparison with patients' self-reported complications in the questionnaires (response rate, 95%). Furthermore, a comprehensive mortality follow-up for participants not returning the questionnaires was conducted. For this purpose, follow-up data were obtained from population registries and the local public health authorities.

In addition, this study has limitations mainly resulting from the data quality of colonoscopy records. Firstly, this analysis was restricted to bleeding and perforations. Cardiopulmonary complications have been described in the literature as an additional complication after screening colonoscopy. In the colonoscopy records used in our study, however, cardiopulmonary complications were not recorded. Secondly, it was not possible to differentiate between minor and major bleeding due to the lack of unambiguous definition and documentation of bleeding in medical records—a

differentiation would be highly desirable. Finally, we were not able to link our data with information regarding the qualification and training of the participating gastroenterologists (25).

Conclusion

This large prospective study underlines the need to consider the post-colonoscopy period in the comprehensive evaluation of screening colonoscopy complications. At the same time our analysis confirms that the complication rate for screening colonoscopy is low even with careful consideration of any complications arising in the four weeks following the intervention. This underlines the safety of screening colonoscopy in a setting with adequate quality assurance such as the German screening colonoscopy program. In particular, complications are extremely rare in participants without colorectal neoplasms, who do have immediate benefits from screening colonoscopy.

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Conflict of interest statement

The authors declare that no conflict of interests exist.

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REFERENCES

1. Ferlay J, Soerjomataram I, Ervik M, et al.: GLOBOCAN 2012 v1.0, Cancer Incidence and Mortality Worldwide: IARC CancerBase No. 11. Lyon, France: International Agency for Research on Cancer; 2013. Available from: <http://globocan.iarc.fr> (last accessed on 27 July 2016).
2. Atkin WS, Edwards R, Kralj-Hans I, et al.: Once-only flexible sigmoidoscopy screening in prevention of colorectal cancer: a multicentre randomised controlled trial. *Lancet* 2010; 375: 1624–33.
3. Segnan N, Armaroli P, Bonelli L, et al.: Once-only sigmoidoscopy in colorectal cancer screening: follow-up findings of the Italian randomized controlled trial—SCORE. *J Natl Cancer Inst* 2011; 103: 1310–22.
4. Schoen RE, Pinsky PF, Weissfeld JL, et al.: Colorectal-cancer incidence and mortality with screening flexible sigmoidoscopy. *N Engl J Med* 2012; 366: 2345–57.
5. Holme Ø, Løberg M, Kalager M, et al.: Effect of flexible sigmoidoscopy screening on colorectal cancer incidence and mortality: a randomized clinical trial. *JAMA* 2014; 312: 606–15.
6. Brenner H, Stock C, Hoffmeister M: Effect of screening sigmoidoscopy and screening colonoscopy on colorectal cancer incidence and mortality: systematic review and meta-analysis of randomised controlled trials and observational studies. *BMJ* 2014; 348: g2467.

KEY MESSAGES

- This large prospective study aimed to comprehensively assess the frequency of complications arising during and within four weeks after screening colonoscopy.
- The rate of complications is low even with careful consideration of any complications arising in the four weeks following the examination, underlining the safety of screening colonoscopy in a setting with comprehensive quality assurance such as the German screening colonoscopy program.
- In particular, complications are extremely rare in participants without colorectal neoplasms, who do not have immediate benefits from screening colonoscopy.
- Our findings underline the need to consider the post-colonoscopy period in the comprehensive evaluation of screening colonoscopy complications.

- Castro G, Azrak M, Seeff L, Royalty J: Outpatient colonoscopy complications in the CDC's colorectal cancer screening demonstration program: a prospective analysis. *Cancer* 2013; 119, Suppl 15: 2849–54.
- Rutter C, Johnson E, Miglioretti D, Mandelson M, Inadomi J, Buist D: Adverse events after screening and follow-up colonoscopy. *Cancer Causes Control* 2012; 23: 289–96.
- Nelson D, McQuaid K, Bond J, Lieberman D, Weiss D, Johnston T: Procedural success and complications of large-scale screening colonoscopy. *Gastrointest Endosc* 2002; 55: 307–14.
- Imperiale T, Wagner D, Lin C, Larkin G, Rogge J, Ransohoff D: Risk of advanced proximal neoplasms in asymptomatic adults according to the distal colorectal findings. *N Engl J Med* 2000; 343: 169–74.
- 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.
- Crispin A, Birkner B, Munte A, Nusko G, Mansmann U: Process quality and incidence of acute complications in a series of more than 230 000 outpatient colonoscopies. *Endoscopy* 2009; 41: 1018–25.
- Bokemeyer B, Bock H, Huppe D, et al.: Screening colonoscopy for colorectal cancer prevention: results from a German online registry on 269 000 cases. *Eur J Gastroenterol Hepatol* 2009; 21: 650–5.
- Lee TJW, Rutter MD, Blanks RG, et al.: Colonoscopy quality measures: experience from the NHS bowel cancer screening programme. *Gut* 2012; 61: 1050–7.
- Regula J, Rupinski M, Kraszewska E, et al.: Colonoscopy in colorectal-cancer screening for detection of advanced neoplasia. *N Engl J Med* 2006; 355: 1863–72.
- Suissa A, Bentur O, Lachter J, et al.: Outcome and complications of colonoscopy: a prospective multicenter study in northern Israel. *Diagn Ther Endosc* 2012; 2012: 612542.
- Pox CP, Altenhofen L, Brenner H, Theilmeier A, von Stillfried D, Schmigel W: Efficacy of a nationwide screening colonoscopy program for colorectal cancer. *Gastroenterology* 2012; 142: 1460–7.e2.
- Adler A, Lieberman D, Ainalai A, et al.: Data quality of the German screening colonoscopy registry. *Endoscopy* 2013; 45: 813–8.
- Stock C, Ihle P, Sieg A, Schubert I, Hoffmeister M, Brenner H: Adverse events requiring hospitalization within 30 days after outpatient screening and nonscreening colonoscopies. *Gastrointest Endosc* 2013; 77: 419–29.
- Brenner H, Haug U, Arndt V, Stegmaier C, Altenhofen L, Hoffmeister M: Low risk of colorectal cancer and advanced adenomas more than 10 years after negative colonoscopy. *Gastroenterology* 2010; 138: 870–6.
- Brenner H, Hoffmeister M, Arndt V, Stegmaier C, Altenhofen L, Haug U: Protection from right- and left-sided colorectal neoplasms after colonoscopy: population-based study. *J Natl Cancer Inst* 2010; 102: 89–95.
- Hoffmeister M, Schmitz S, Karmrodt E, et al.: Male sex and smoking have a larger impact on the prevalence of colorectal neoplasia than family history of colorectal cancer. *Clin Gastroenterol Hepatol* 2010; 8: 870–6.
- Tao S, Hoffmeister M, Brenner H: Development and validation of a scoring system to identify individuals at high risk for advanced colorectal neoplasms who should undergo colonoscopy screening. *Clin Gastroenterol Hepatol* 2014; 12: 478–85.
- Statistisches Amt Saarland: Sterbetafel 2013/2015 (männlich/weiblich). www.saarland.de/6772.htm (last accessed on 23 February 2017).
- Adler A, Wegscheider K, Lieberman D, et al.: Factors determining the quality of screening colonoscopy: a prospective study on adenoma detection rates, from 12 134 examinations (Berlin colonoscopy project 3, BECOP-3). *Gut* 2012; 62: 236–41.

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Supplementary material

eTable:

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Supplementary material to:

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eTABLE

Overview of studies reporting the frequency of complications associated with screening colonoscopy

Ref.	First author, year	Study period	Country	Study type	Age of participants (years)	No of screening colonoscopies (n)	Bleedings (n)	Perforations (n)	Period assessed following colonoscopy
(7)	Castro. 2013	2005–2009	USA	prospective	Mean 60 (SD 5.7)	3355	1 (0.03%)	3 (0.09%)	30 days
(14)	Lee. 2012	2006–2009	UK	prospective	60–74	36 460	49 (0.13%)	35 (0.09%)	directly after colonoscopy
(17)	Pox. 2012	2003–2008	Germany	prospective	55+	2 821 392	573 (0.29/1000)*	439 (0.22/1000)*	directly after colonoscopy
(8)	Rutter. 2012	1994–2009	USA	retrospective	40–85	38 472	103 (0.27%)	15 (0.04%)	30 days
(16)	Suissa. 2012	2003–2006	Israel	prospective	57 (SD 15)	6584	3 (0.05%)	3 (0.05%)	7 days
(13)	Bokemeyer. 2009	2003–2006	Germany	prospective	55+	269 114	442 (0.16%)	55 (0.02%)	4 weeks
(12)	Crispin. 2009	2006	Germany	prospective	Mean 64	55 993	134 (0.24%)	22 (0.04%)	directly after colonoscopy
(15)	Regula. 2006	2000–2004	Poland	prospective	40–66 (Mean 55)	50 148	13 (0.03%)	5 (0.01%)	30 days
(9)	Nelson. 2002	1994–1997	USA	prospective	50–75 (Mean 63)	3196	13 (0.41%)	–	24 hours to 7 days after colonoscopy
(10)	Imperiale. 2000	1995–1998	USA	prospective	Mean 60	2886	3 (0.11%)	1 (0.04%)	directly after colonoscopy
(11)	Lieberman. 2000	1994–1997	USA	prospective	50+ (Mean 63)	3121	6 (0.19%)	–	directly after colonoscopy

* Including severe complications with (bleedings: 0.92/1000, perforations: 0.46/1000) and without polypectomy (bleedings: 0.01/1000, perforations: 0.12/1000) SD, standard deviation