

## Retrospective Study

## Patient age and duration of colonoscopy are predictors for adenoma detection in both proximal and distal colon

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### Abstract

**AIM:** To investigate the relation of patient characteristics and procedural parameters to the endoscopic detection rate of colonic adenomas. Further to study,

which factors may be capable to predict the localization of adenomatous lesions.

**METHODS:** We used the data base of a prospective randomized colonoscopy study (The ColoCap trial) to identify patients being diagnosed with colon adenoma. Logistic regression analysis was conducted to reveal predictors for adenoma detection in the entire colon and also with respect to the proximal and distal part. Covariates including age, gender, duration of colonoscopy and comorbidities were defined to determine association between predictors and adenoma detection.

**RESULTS:** Equal numbers of adenomas were detected in the proximal and distal side of the splenic flexure [126 (57%) vs 94 (43%),  $P = 0.104$ ]. Simultaneous occurrence of adenomas in both sides of the colon was rare. The appearance of both proximal and distal adenoma was associated with increasing age ( $P = 0.008$  and  $P = 0.024$ ) and increasing duration of colonoscopy ( $P < 0.001$  and  $P = 0.001$ ). Male gender was a predictor for adenoma detection in the proximal colon ( $P = 0.008$ ) but statistical significance was slightly missed with respect to the distal colon ( $P = 0.089$ ). Alcohol abuse was found to be a predictor for the detection of distal adenoma ( $P = 0.041$ ).

**CONCLUSION:** Increasing age and longer duration of colonoscopy are factors with a strong impact on adenoma detection both in the proximal and distal colon. Since proximal adenomas occurred in absence of distal adenomas, complete colonoscopy should be performed for screening.

**Key words:** Adenoma; Colorectal carcinoma; Distal; Colonoscopy; Proximal

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**Core tip:** In this post-hoc study of a prospective randomized trial we analysed the impact of predefined patients and procedural characteristics on adenoma detection. Proximal lesions are at risk for being missed during colonoscopy but data is sparse regarding the existence of specific predictors for the detection of proximal and distal adenomas. Therefore, in our analysis we computed side specific regression analysis in order to define those predictors. Male gender, longer duration of colonoscopy procedure and increasing age were predictors for both proximal and distal adenomas. Proximal adenomas frequently occurred in the absence of distal adenomatous lesions. We therefore suggest total colonoscopy instead of sigmoidoscopy for colorectal cancer screening.

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## INTRODUCTION

The endoscopic detection and resection of adenomatous polyps in the colon is the gold standard for colorectal cancer (CRC) prevention. Many countries have established screening colonoscopy programs, which has led to a decrease in CRC incidence<sup>[1]</sup>. However, there is controversial, whether both distal and proximal colonic malignancies can sufficiently be prevented by screening colonoscopy. Lesions located in the cecum, ascending and transverse colon and splenic flexure are usually assigned to the right (or proximal) colon, whereas the left colon includes the descending and sigmoid colon as well as the rectum<sup>[2]</sup>. Some studies have suggested that benefits from colorectal cancer screenings are stronger for the left than for the right side of the colon<sup>[3,4]</sup>. This fact has led to a new debate on the significance of flexible sigmoidoscopy as the primary screening method<sup>[5,6]</sup>. In fact, little is known about the local distribution of adenomas in the large intestine. The adenoma detection rate is an essential colonoscopy quality indicator and is applied for the entire colon<sup>[7,8]</sup>. So far, it has not been investigated if the acquisition of separate adenoma detection rates for both proximal and distal colon sections may be useful. If the frequency or appearance of proximal adenoma was different from distal lesions, one would also have to ask which factors may influence the respective pattern. Until now, no side-specific risk factors have been established. Only few studies have focused on a possible heterogeneity between proximal and distal adenomatous lesions and emphasized the impact of epidemiological factors on the local distribution<sup>[9-11]</sup>.

The aim of this study therefore was to determine

patient characteristics as well as procedural measurements, which affect the detection of proximal and distal colon adenomas. As we conducted a post-hoc analysis of a former patient safety study another focus was placed on sedation related variables.

## MATERIALS AND METHODS

We used the database of a large prospective randomized trial (ColoCap Study) which was conducted at three centers in Germany between January 2010 and January 2011<sup>[12]</sup>. The aim of the ColoCap Study was to determine the value of capnography as a tool for detection and monitoring apnea during colonoscopy under propofol sedation<sup>[12]</sup>. For a post-hoc analysis pathological data of patients and resected lesions were abstracted by reviewing patient medical records and the institutional electronic charting system.

Procedures were done with standard white light video-colonoscopes. All polyps were resected by forceps biopsy or snare polypectomy according to national guidelines<sup>[7]</sup> and sent for pathological investigation.

According to histopathological findings lesions were divided in the following categories: no pathology, hyperplastic polyp, adenoma (tubular, villous, serrated) and carcinoma. We defined adenocarcinoma as well as adenoma which presented villous histology as “advanced lesions”. An advanced lesion was also registered in case if adenoma were greater than or equal 10 mm in size regardless of further histopathological findings. Lesions were divided into two groups depending on the area of detection. We defined the right colon to begin with the cecum reaching up to (and including) the splenic flexure. All polyps which were found in this part were grouped under the term “right sided” or “proximal lesions”. Lesions that were harvested further down were assigned to the left (or distal) colon.

We summarized variables dealing with patient safety and monitoring under the category “procedural characteristics”. These included the amount of sedatives used, occurrence of hypoxemia and bradycardia but also duration of colonoscopy. Patient characteristics as well as colonoscopy findings were grouped into two other categories of variables. Variables of all three categories were analyzed in order to reveal possible predictors for the detection of colonic lesions. The post-hoc analysis was approved by the Ethics Committee of the Technical University of Munich (project number: 5793/13).

### Statistical analysis

Descriptive statistics of continuous and categorical data are given by mean, range, and absolute and relative frequencies. Uni- and multivariate analysis were performed by logistic regression. In case of semi-complete separation, Firth’s penalized-likelihood logistic regression was used for a robust estimation of the odds ratio. 95%CI are presented for the latter. For categorical data the odds ratio describes the ratio of odds of a

**Table 1 Patient and procedural characteristics of 551 cases included in the analysis**

Patients	
Age (yr)	62 (18-90)
Gender: male/female	285 (52)/266 (48)
Setting: in-patient/out-patient	298 (54)/249 (46)
BMI	24.8 (15.1-41.5)
Sleep apnea syndrome: yes/no	17 (3)/528 (97)
Previously known sedation related complications: no/yes	540 (99)/7 (1)
ASA classification: I / II / III	160 (29)/215 (39)/173 (32)
Lung disease: yes/no	59 (11)/489 (89)
Heart disease: yes/no	132 (24)/416 (76)
Procedural measurements and safety monitoring	
Using capnography	267 (50)
Investigation time (min)	32 (2-126)
Hypoxemia (at least one episode)	241 (44)
Hypoxemia (pO <sub>2</sub> < 90%; at least one episode)	71 (13)
Hypoxemia (pO <sub>2</sub> < 85%, at least one episode)	23 (4)
Hypotension (at least one episode)	10 (2)
Bradycardia (at least one episode)	50 (9)
Using midazolam	57 (10)
Using propofol	526 (95)
Propofol dose (mg)	140 (0-800)

Numbers are mean values (range: minimum-maximum) or frequencies (percentages). BMI: Body mass index.

category and the reference category. In continuous data it describes the ratio of odds of a subject with value  $x + 1$  and a subject with value  $x$ . In detail, odds ratio describes the quotient of chances to reveal one characteristic (*e.g.*, “adenoma”) dependent whether one predefined factor is present or not. For example, this factor might be patient age.  $x + 1$  would mean to increase age by one unit (year). Likewise, for categorical data the odds ratio describes the ratio of odds of a category and the reference category. Dichotomization of continuous variables was not done due to the potential loss of information. All analyses were performed in an explorative manner on a 5% significance level. IBM SPSS Statistics 20 (SPSS inc., Chicago, IL, United States) and the statistical software package R 2.15.1 (The R Foundation for Statistical Computing, Vienna, Austria) were used for computation.

## RESULTS

### Patient and procedural characteristics

Complete data were available from 610 in- and outpatient patients. Fifty-nine colonoscopies were excluded because of indications referred to as “polypectomy”, “evaluation of known CRC”, “inflammatory bowel disease” and “polyposis syndrome”. Thus, a total of 551 records were analyzed. Ninety-nine patients (18%) were admitted to colonoscopy for screening. Additionally, 39 (7%) were investigated because of former polypectomy (surveillance). Rectal bleeding or anemia and abdominal discomfort comprised 167 (30%) and 155 (28%) of all cases. Patients had a mean age of 62 years, gender

**Table 2 Colonoscopy outcome and Procedural findings (n = 551) n (%)**

Finding	Total/detection rate
Colonic lesions (entire colon)	
Lesions total (polyps, adenomas, carcinomas)	430
Polyps	412
Adenomas	220
Advanced adenomas	41
Carcinomas	18
Polyp detection rate <sup>1</sup>	37%
Adenoma detection rate <sup>1</sup>	22%
Cases with at least 1 adenoma	121
Cases with 2 or more adenomas	46
Other colonic pathology	
Hemorrhoids	19 (3)
Stenosis	4 (1)
Angiodysplasia	14 (3)
Diverticula	53 (10)
Mucosal Bleeding	5 (1)
Mucosal inflammation	86 (16)

<sup>1</sup>Detection rates were defined as number of colonoscopies in which one or more lesion was found divided by the number of colonoscopies performed.

was distributed evenly (285 male, 266 female). Patient characteristics including use of drink and tobacco and medical history are shown in Table 1.

Colonoscopy took at mean 32 min. Almost all patients (526, 95%) received propofol whereas midazolam was administered in only 57 cases (10%). Mean propofol dose was 140 mg per session (range: 0-800 mg). Episodes of hypoxemia (at least one episode of decrease of oxygen saturation  $\geq 5$  percentage points or oxygen saturation < 90%) were observed in 241 cases (44%). Frequency was much lower when only the latter definition of hypoxemia (oxygen saturation < 90%) was considered (71 cases, 13%). Patient monitoring data is shown in Table 1.

### Pathology

A total of 430 colonic lesions were detected including 220 adenomas. Among them were 41 advanced lesions (19%) including 18 adenocarcinomas. Polyp and adenoma detection rates (defined as numbers of colonoscopies with at least one lesion divided by total amount of records) were 37% and 22%, respectively. More than one adenomatous lesion was found in 8% of all colonoscopies. We found at least one advanced adenoma in 36 (7%) cases.

In 104 of 121 cases (86%) in which adenomas were found, lesions were resected immediately after detection. Resection was performed using biopsy forceps in 53 (44%) and polypectomy snare in 49 cases (40%). In 2 cases no data on the mode of resection was available. In 17 cases (14%) lesions were not resected in the same session when they were detected. Besides polypoid lesions and carcinoma colonoscopies revealed further findings which are listed in Table 2. The most frequent pathology was mucosal inflammation, which was described in 16% of all cases.

**Global adenoma detection rate**

**Univariate analysis:** Increasing age and male gender were significantly associated with adenoma detection ( $P < 0.001$ , OR = 1.026, 95%CI: 1.012-1.1041 and  $P = 0.003$ , OR = 0.535, 95%CI: 0.353-0.812). The definition of odds ratio is described in the statistical section of “Materials and Methods”. Therefore, regarding age, an OR of 1026 can be interpreted as meaning that every additional patient year increased the risk (odds) of detecting at least one adenoma by 2.6%. For the categorical parameter sex the abovementioned odds ratio of 0.535 means that female gender decreased the risk for harvesting adenoma by 53%. Regarding lifestyle both, the use of tobacco and alcohol intake significantly predicted adenoma detection ( $P = 0.019$ , OR = 0.610, 95%CI: 0.404-0.921 and respectively  $P = 0.050$ , OR = 0.538, 95%CI: 0.290-1.000). Body composition or comorbidities were not associated with adenoma detection.

Increasing investigation time was a significant factor for detecting adenoma. Every additional minute increased the chance to detect at least one adenomatous polyp by 2.7% ( $P < 0.001$ , OR = 1.027, 95%CI: 1.018-1.037). Furthermore, patients who had suffered from sedation problems during endoscopic procedures in the past were at higher risk for revealing adenoma ( $P = 0.041$ , OR = 0.207, 95%CI: 0.046-0.940). The amount of propofol used in one session predicted the detection of adenomas but missed statistical significance slightly. Indication for colonoscopy was a predictor for adenoma detection ( $P < 0.001$ ). Odds ratio for the indication “suspected tumor” was 3.676 (95%CI: 1.118-12.018). Other procedural characteristics like colonoscopy time schedule (earlier/later in the day) or sedation related complications (hypoxemia, hypotension and others) had no impact on adenoma detection.

The occurrence of inflammation (at least one inflamed area described during colonoscopy) was significantly associated with lower adenoma detection ( $P < 0.001$ , OR = 9.408, 95%CI: 2.918-30.333).

**Multivariate analysis:** Regarding the whole colon both increasing age and male gender were stable variables to predict adenoma detection ( $P = 0.002$ , OR = 1.032, 95%CI: 1.012-1.053 and  $P = 0.007$ , OR = 0.507, 95%CI: 0.309-0.832). In contrast, lifestyle factors (drink and tobacco) were no longer significant predictors after controlling for confounders.

Longer investigation time remained significantly associated with increased detection of adenomatous lesion in multivariate analysis ( $P < 0.001$ , OR = 1.033, 95%CI: 1.019-1.048). Indication for colonoscopy also predicted adenoma detection ( $P < 0.001$ ). Odds ratio for the indication “suspected tumor” was 3.399 (95%CI: 0.859-12.914). All other procedural and safety measurements failed statistical significance. Similarly, mucosal inflammation as an endoscopic finding was no longer evident after adjusting for confounders by regression analysis.

**Advanced lesions**

We found 41 advanced adenomas. Among these, 18 lesions were classified as adenocarcinomas. Advanced adenoma detection rate was 7%. In univariate analysis increasing age ( $P = 0.004$ , OR = 1.040, 95%CI: 1.013-1.067), male gender ( $P = 0.014$ , OR = 0.389, 95%CI: 0.184-0.823), longer duration of colonoscopy ( $P < 0.001$ , OR = 1.032, 95%CI: 1.018-1.045), inpatient setting ( $P = 0.001$ , OR = 0.190, 95%CI: 0.072-0.499), colonoscopy performed later in the day ( $P < 0.001$ , OR = 1.412, 95%CI: 1.189-1.678) and higher propofol doses ( $P = 0.024$ , OR = 1.003, 95%CI: 1.000-1.005) were predictors for the detection of advanced lesions. Every additional hour that endoscopy started later, the chance to detect an advanced lesion rose by 40%. Indication for colonoscopy was also a predictor for the detection of advanced adenomas ( $P < 0.001$ ). Odds for the indication “suspected tumor” was 6.942 (95%CI: 0.869-55.480). No multivariate regression analysis was performed in this sub-setting of the analysis due to the rarity of the outcome.

**Serrated adenoma**

Pathologic investigation revealed a serrated phenotype in six out of 220 adenomas. Five of these six serrated lesions were located in the distal colon. Only one serrated adenoma (SA) located in the distal colon was assessed as an advanced lesion. Predictors for SA detection was indication for colonoscopy [(anemia/bleeding),  $P = 0.002$ , OR = 0.063, 95%CI: 0.000-0.603] and higher propofol dose ( $P = 0.037$ , OR = 1.004, 95%CI: 1.000-1.009). Multivariate regression analysis was again not performed in this sub-setting due to the rarity of the outcome.

**Comparing lesions in the proximal and distal colon**

**Side-specific adenoma detection rates:** The total count of adenoma was not significantly different in the right and in the left colon [126 (57%) *vs* 94 (43%),  $P = 0.104$ ]. Twenty-three proximal and eighteen distal adenomas were classified as advanced lesions. The local distribution of carcinomas was equal between both sides (9 *vs* 9). Adenoma detection rates were similar in the proximal and distal colon (13% respectively). Furthermore we found no difference with respect to the detection of advanced lesions (3% both). Simultaneous occurrence of adenoma in both parts of the colon was noticed in only 4% (22/551) of all cases. In no case advanced lesions were found simultaneously on both sides of the colon. Descriptive data regarding site-specific detection rates of colon lesions is given in Table 3.

**Predictors for proximal adenoma detection:** In the proximal colon increasing age ( $P < 0.001$ , OR = 1.034, 95%CI: 1.015-1.053), male gender ( $P = 0.002$ , OR = 0.434, 95%CI: 0.255-0.741), increasing duration of colonoscopy ( $P < 0.001$ , OR = 1.030, 95%CI: 1.019-1.041), indication for procedure [ $P < 0.001$ , OR = 1.949 (“Suspected tumor”), 95%CI: 0.510-7.445], tobacco abuse ( $P = 0.005$ , OR = 0.470, 95%CI: 0.279-0.792)

**Table 3** Local distribution of colon adenomas in 551 cases *n* (%)

Finding	Total/detection rate
Adenomatous lesion in the right colon	
Adenomas	126
Adenoma detection rate <sup>1</sup>	13%
Advanced adenomas	23
Advanced adenoma deletion rate	19 (3)
Adenomatous lesion in the left colon	
Adenomas	94
Adenoma detection rate <sup>1</sup>	13%
Advanced adenomas	18
Advanced adenoma deletion rate	17 (3)
Simultaneous detection of lesions (Cases with at least one adenoma in both right and left colon)	
Adenomas	22 (4)
Advanced adenomas	0

<sup>1</sup>Detection rates were defined as number of colonoscopies in which one or more lesion was found divided by the number of colonoscopies performed.

and mucosal inflammation ( $P = 0.010$ , OR = 4.763, 95%CI: 1.463-15.504) predicted adenoma detection in univariate analysis. However, only age ( $P = 0.008$ , OR = 1.036, 95%CI: 1.010-1.064), gender ( $P = 0.008$ , OR = 0.425, 95%CI: 0.227-0.797) and duration of endoscopy ( $P < 0.001$ , OR = 1.039, 95%CI: 1.022-1.056) remained significant factors after controlling for confounders.

**Predictors for distal adenoma detection:** In the distal colon increasing age ( $P = 0.024$ , OR = 1.029, 95%CI: 1.004-1.054) and increasing investigation time ( $P = 0.001$ , OR = 1.027, 95%CI: 1.011-1.044) were also associated with improved adenoma detection in the multivariate setting. Male gender was a significant factor in the univariate analysis ( $P = 0.026$ , OR = 0.553, 95%CI: 0.329-0.931) but missed the level of statistical significance slightly after controlling for confounders ( $P = 0.089$ ). Alcohol intake was a predictor for adenoma detection ( $P = 0.041$ , OR = 0.438, 95%CI: 0.198-0.967). After adjusting for confounders, patients rated as alcohol abusers were at a 44% higher risk for revealing adenoma compared to abstainers. Regarding procedural measurements a history of previously sedation problems ( $P = 0.032$ , OR = 0.190, 95%CI: 0.042-0.866), increasing propofol dose ( $P = 0.011$ , OR = 1.002, 95%CI: 1.001-1.004) and indication for colonoscopy [ $P < 0.001$ , OR = 7.560 (“suspected tumor”), 95%CI: 0.947-60.343] predicted adenoma detection in the left colon. However, only indication for colonoscopy ( $P = 0.013$ ) was statistically significant in multivariate analysis [OR = 6.599 (“suspected tumor”), 95%CI: 0.756-75.586]. Two colonoscopy findings (absence of diverticula and mucosal inflammation) were significant factors in univariate analysis ( $P = 0.037$ , OR = 8.403, 95%CI: 1.143-61.779 and  $P = 0.035$ , OR = 0.032, 95%CI: 0.001-0.227). As these two variables were not predefined as relevant confounders, they were not subject to multivariate testing.

## DISCUSSION

The adenoma detection rate is an established quality indicator for colonoscopy<sup>[13]</sup>. A total detection rate of 20% has been defined as a landmark in screening colonoscopy<sup>[14,15]</sup>. Adenomatous lesions can occur both in the proximal and distal part of the colon but information is sparse regarding the local distribution<sup>[16]</sup>. In the past the focus was placed on distal malignancies<sup>[17]</sup> with flexible sigmoidoscopy propagated as a sufficient tool for detection and surveillance. Advocators of flexible sigmoidoscopy argue that screening colonoscopy has not met expectations insofar as proximal cancer has not been prevented sufficiently<sup>[3,4,18,19]</sup>. Moreover, sigmoidoscopy has been shown to be effective in reducing cancer in several countries<sup>[20-22]</sup>. However, there are also some hints that premalignant polypoid lesions might be missed on the left side<sup>[23,24]</sup>. Little is known about possible risk factors for proximal or distal adenomas respectively.

In this study we sought to describe characteristics of adenomatous lesions separated by the splenic flexure and to reveal factors which affect side-specific adenoma detection. As we considered data from a former patient safety study another focus laid on sedation-related and procedural measurements as well as on available patient characteristics.

### **Simultaneous occurrence of proximal and distal adenoma is rare**

We found a total of 220 adenomatous lesions and determined a total adenoma detection rate of 22%. As the main finding of this study, the amount of adenoma harvested from the proximal colon did not differ significantly from the count harvested from the distal part (57% *vs* 43%). Furthermore, advanced lesions and carcinomas were found with an almost similar distribution on both sides. In a recent study Boroff *et al*<sup>[16]</sup> found a significantly higher adenoma detection rate in the right colon. Diminutive proximal adenomas are of special interest since a remarkable miss-rate is suspected regarding these lesions<sup>[25]</sup>. Worthy to note, serrated adenomas, especially the sessile serrated subtype, may present as such small and difficult to detect polyps<sup>[26]</sup>. Some data suggest that missing these premalignancies may contribute to an increasing risk of developing proximal colon cancer<sup>[27,28]</sup>. In our investigation six out of 220 adenomas (3%) were serrated lesions. This quota is in agreement with the range reported in the literature<sup>[29]</sup>. Contrary to the knowledge that serrated lesions frequently occur in the proximal part of the colon, our results revealed a surplus of serrated adenomas in the distal part. This finding might be due to the low number of serrated lesions detected in our study.

Most importantly, simultaneous occurrence of any kind of adenomas in both the proximal and distal colon was rare. Moreover, we did not detect advanced lesions on both sides of the splenic flexure in any patient. This finding underlines the importance of screening

the whole colon instead of performing sigmoidoscopy. Inspecting only the distal part of the colon would mean to accept the risk of missing a relevant number of cancer precursors in the right colon.

### **Male gender and advanced age are risk factors for both proximal and distal adenomas**

We found that older patients and males were exposed to increased risk for revealing adenoma. This relation is already well known with regard for the whole colon<sup>[7,8]</sup>. Although male gender did not reach statistical significance in multivariate analysis for the left colon still a clear trend was obvious. Therefore, age and gender seem to influence the probability of revealing adenoma similarly in both the proximal and distal colon. Furthermore, in univariate analysis we found smoking to be associated with the occurrence of proximal colon adenoma. Coincidence between use of tobacco and colorectal findings has been studied repeatedly and in most cases smoking was assessed to be a predictor for premalignant neoplasia or carcinoma<sup>[30-32]</sup>. In a recent study smoking was deemed to bear the risk for proximal CRC<sup>[33]</sup>. These data are supported by our findings. In contrast there are also publications in which smoking was rather suggested to promote distal lesions<sup>[11]</sup>. Concerning alcohol consumption we found drinker to be at a 40% higher risk of revealing distal adenomas than abstainers. This influence was stable in both uni- and multivariate analysis. Alcohol intake as a risk factor for colorectal neoplasia was studied before. In most of these trials the effect of alcohol was weak or only observed in subgroups<sup>[30]</sup>. Regarding adenoma locality one study showed that regular intake of spirit drinks was associated with left sided adenoma<sup>[34]</sup>. However, no increased risk (nor for proximal neither for distal adenoma) was observed in a newer case-control study containing 628 adenoma cases<sup>[11]</sup>. In summary, data seems to be inconsistent and sparse. Further studies should be conducted to specify the relevance of alcohol drinking in colorectal (pre)neoplastic lesions.

### **Procedural measurements: Duration of colonoscopy has impact on adenoma detection**

At present, a withdrawal time of at least 6 min is classified as a quality indicator in colonoscopy<sup>[7,35]</sup>. Due to the retrospective study design we were not able to measure the withdrawal time and no data was available regarding the length of mucosal observation in each particular colon segment. In addition, one major limitation of this analysis derives from the fact that we were not able to subtract expenditure of time which was needed for the conduction of polypectomy itself. This fact may have resulted in a bias. In 14% of all cases in which adenomas were found polypectomy was not conducted during the same session and in further 44% resection was carried out immediately using the biopsy forceps which suggests that in the majority of cases bias might have been rather low. Anyway, due to the retrospective design of our study

the data is not capable to prove unambiguously that observation time and not polypectomy itself explain our results. Interestingly, duration of procedure had a strong impact on both proximal and distal adenoma detection. To investigate whether independent observation times may lead to differences in segment-specific adenoma detection further studies should be conducted.

As expected, indication for colonoscopy was a predictor for adenoma detection in our study. As odds were high in cases where tumors were suspected prior to the investigation this finding is comprehensible and noncritical. Regarding the safety of colonoscopy we could not find an association between sedation problems such as hypoxemia or hypotension and a lower adenoma detection rate. However, some other sedation-related measurements were noticeable. We found that a history of former sedation-related complications as well as increasing dose of propofol were predictors of increased adenoma detection in the distal colon but not in the proximal part. The required amount of propofol varies highly between patients and in part depends on age, indication of colonoscopy and physical condition<sup>[36-38]</sup>. It might be argued that age and comorbidities affect the occurrence of adenoma as well as sedation problems. Until now, no sedation-induced effect on adenoma detection has been verified<sup>[39]</sup>.

### **Limitations**

Our study is subject to some limitations. First, since we conducted a post hoc analysis of a former colonoscopy study the retrospective view implies a major restriction. Second, due to the rarity of advanced and serrated adenomas only univariate analysis was performed with respect to these lesions. These results should be interpreted with caution as possible confounders might not be eliminated. In particular, predictors for advanced lesions like inpatient setting and colonoscopy scheduled later in the day must be interpreted with caution since inpatients are investigated later in the day for organizational reasons. Third, in our setting we were faced with a mixed patient population undergoing colonoscopy for a multitude of indications which prevents transferring the results to a cancer screening scenario and procedures were conducted at a single tertiary referral center which might explain the high proportion of advanced lesions and carcinoma that were detected. Finally, in our data we were not able to provide information about quality of bowel preparation, a factor which influences adenoma detection.

In summary, our data support the assumption that male gender, advanced age and a longer duration of colonoscopy are related with increasing rates of adenoma detection. This finding applies to both proximal and distal adenomatous lesions. We found no evidence that sedation related complications influence adenoma detection. Furthermore, our data reveal that proximal lesions often occur in the absence of distal adenomas. Therefore, total colonoscopy should be preferred to

sigmoidoscopy in case of colorectal cancer screening.

## COMMENTS

### Background

To determine predictors for the detection of proximal and distal adenomas.

### Research frontiers

Adenomas in the proximal colon are at risk of being missed during screening colonoscopy.

### Innovations and breakthroughs

Patient age, male gender and duration of colonoscopy were predictors for both proximal and distal adenoma detection. Proximal adenomas were detected frequently in absence of distal adenomatous lesions.

### Applications

Full colonoscopy should be performed instead of sigmoidoscopy for the detection of cancer precursors.

### Terminology

Adenomatous polyps detected in the cecum, ascending or transverse colon are defined as "proximal adenomas".

### Peer review

This paper is an interesting study on the factors influencing the adenoma detection rate in colonoscopy. The authors use a colonoscopy database designed for other aims which make it easy to avoid bias in patient selection.

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