

## Surveillance of colonic polyps: Are we getting it right?

Stewart N Bonnington, Matthew D Rutter

Stewart N Bonnington, Matthew D Rutter, Department of Gastroenterology, University Hospital of North Tees, Stockton-on-Tees TS19 8PE, United Kingdom

Stewart N Bonnington, Matthew D Rutter, Durham University, Stockton-on-Tees TS17 6BH, United Kingdom

**Author contributions:** Bonnington SN performed the literature review and wrote the manuscript; and Rutter MD reviewed and amended the manuscript and advised on content.

**Conflict-of-interest statement:** Stewart N Bonnington and Matthew D Rutter declare no conflict of interest.

**Open-Access:** This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

**Correspondence to:** Dr. Stewart N Bonnington, Department of Gastroenterology, University Hospital of North Tees, Hardwick Road, Stockton-on-Tees TS19 8PE, United Kingdom. [sbonnington@doctors.org.uk](mailto:sbonnington@doctors.org.uk)  
Telephone: +44-1642-624557  
Fax: +44-1642-383289

Received: July 27, 2015

Peer-review started: July 30, 2015

First decision: August 31, 2015

Revised: October 15, 2015

Accepted: November 24, 2015

Article in press: November 24, 2015

Published online: February 14, 2016

### Abstract

Colorectal cancer (CRC) is the third most commonly diagnosed cancer worldwide. The identification of colonic polyps can reduce CRC mortality through earlier diagnosis of cancers and the removal of polyps: the

precursor lesion of CRC. Following the finding and removal of colonic polyps at an initial colonoscopy, some patients are at an increased risk of developing CRC in the future. This is the rationale for post-polypectomy surveillance colonoscopy. However, not all individuals found to have colonic adenomas have a risk of CRC higher than that of the general population. This review examines the literature on post-polypectomy surveillance including current international clinical guidelines. The potential benefits of surveillance procedures must be weighed against the burden of colonoscopy: resource use, the potential for patient discomfort, and the risk of complications. Therefore surveillance colonoscopy is best utilised in a selected group of individuals at a high risk of developing cancer. Further study is needed into the specific factors conferring higher risk as well as the efficacy of surveillance in mitigating this risk. Such evidence will better inform clinicians and patients of the relative benefits of colonoscopic surveillance for the individual. In addition, the decision to continue with surveillance must be informed by the changing profile of risks and benefits of further procedures with the patient's advancing age.

**Key words:** Adenoma; Polyp; Colonoscopy; Surveillance; Colorectal cancer

© **The Author(s) 2016.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Core tip:** Increasing numbers of surveillance colonoscopies for previous colonic polyps are being performed. Each colonoscopy brings the burden of bowel preparation, potential discomfort, and risk of complications. Colonoscopy is a finite resource and must be recommended only with a strong indication. Individuals with non-advanced adenomas have no significantly increased risk of colorectal cancer (CRC) compared to the general population. Patients with an advanced adenoma, have a CRC risk similar to that of the general population after just one surveillance colonoscopy. This review examines the evidence behind

current surveillance guidelines and questions the rationale for surveillance in individuals with relatively low cancer risk.

Bonnington SN, Rutter MD. Surveillance of colonic polyps: Are we getting it right? *World J Gastroenterol* 2016; 22(6): 1925-1934 Available from: URL: <http://www.wjgnet.com/1007-9327/full/v22/i6/1925.htm> DOI: <http://dx.doi.org/10.3748/wjg.v22.i6.1925>

## INTRODUCTION

Colorectal cancer (CRC) is the second leading cause of death from cancer in the United Kingdom<sup>[1]</sup> and United States<sup>[2]</sup>. Over 41000 people in the United Kingdom are diagnosed with CRC annually and over 16000 people die of the disease.

Recognised risk factors for the development of CRC include advancing age, a personal or family history of CRC, longstanding inflammatory bowel disease affecting the colon, and specific conditions such as familial adenomatous polyposis (FAP), and hereditary non-polyposis colon cancer (HNPCC). This review focuses on an important risk factor for the development of CRC: a personal history of colorectal adenomas.

Some colonic polyps such as adenomatous and serrated polyps carry malignant potential, while others do not (hyperplastic, post-inflammatory, hamartomatous). This review will discuss only those polyps with malignant potential.

The majority of CRCs arise from colonic adenomas. Adenomas arise following aberrant proliferation of epithelial cells in the colon. These lesions may then progress to varying degrees in size and dysplasia<sup>[3]</sup>. Adenomas represent the major precursor for CRC both in high-risk groups such as patients with a family history of familial adenomatous polyposis (FAP) or hereditary non-polyposis colorectal cancer (HNPCC), as well as in the general population. This concept is termed the "adenoma-carcinoma sequence"<sup>[4-8]</sup>.

However, 20%-30% of colorectal cancers arise through a different molecular pathway to the conventional adenoma-carcinoma sequence. These CIMP-positive cancers (CpG island methylator phenotype) are believed to arise from serrated polyps. Such lesions are over-represented among "interval cancers" (cancers diagnosed 6-36 mo after a colonoscopy)<sup>[9]</sup>. Growing evidence points to the importance of recognising and managing serrated lesions in preventing CRC<sup>[10]</sup>.

The speed of progression along the pathway of proliferation and dysplasia is a key factor in determining clinical practice in patients found to have colonic adenomas. Progression from adenoma to invasive cancer can occur in 5 years or take more than 20 years<sup>[11]</sup>. Additionally, progression along this

pathway is highly variable: one study estimates that only 0.25% of adenomas per year will progress to cancer<sup>[12]</sup>; some stabilise and some regress<sup>[11,13-15]</sup>.

Adenoma prevalence in Western screening populations (age 50-75 years) can be as high as 40%, with advancing age and male sex associated with higher prevalence. However, lifetime risk of CRC is only 5.5% due to the highly variable progression of adenomas<sup>[16-22]</sup>. Overall, projections of 10-year cumulative risk for progression from adenoma to carcinoma are less than 10%<sup>[15,23]</sup>.

## RISK FACTORS

In recent years, an understanding of adenoma features predicting risk of progression to cancer has led to the term "advanced adenoma"<sup>[15]</sup>, referring to adenomas possessing at least one of three high risk characteristics: size of at least 10 mm, villous architecture of at least 25%, or high grade dysplasia<sup>[24-26]</sup>. Overall, these lesions progress to cancer at an annual rate of up to 5%: significantly higher than the average rate for all adenomas<sup>[12]</sup>, and this risk increases with age to 25% at age 55 years and to 40% at age 80 years. Annual rates of progression from adenoma to carcinoma also vary depending on which of these advanced features is present. Size of at least 10 mm confers a 3% annual risk; villous architecture 17%, and high grade dysplasia 37%<sup>[12]</sup>.

As these figures illustrate, high grade dysplasia (HGD) confers high risk of progression to cancer. However, in keeping with the adenoma-carcinoma sequence described previously, high grade dysplasia is more likely to be found in larger lesions: as adenomas progress in size, so too dysplasia progresses<sup>[27]</sup>. The number of adenomas possessing advanced features (HGD or > 25% villous architecture) increases with polyp size from approximately 1%-2% in diminutive adenomas (< 5 mm) to 7%-12% for small adenomas (5-9 mm) and 20%-30% for large adenomas (≥ 10 mm)<sup>[24,28,29]</sup>. Advancing age of the patient also increases the likelihood of HGD within an adenoma, independent of polyp size and histological type<sup>[30]</sup>.

Most adenomas detected at colonoscopy (60%-75%) are smaller than 10 mm diameter<sup>[31]</sup>. Larger adenomas of at least 10 mm in diameter are at higher risk of containing CRC and are also a risk factor for metachronous cancer development (*i.e.*, a cancer diagnosed at least 6 mo after the index procedure)<sup>[24]</sup>. The absolute risk of metachronous advanced adenomas is close to 20% in patients whose largest baseline adenoma is 20 mm or more in size<sup>[32]</sup>.

The risk factor most closely correlating to CRC risk is the total number of adenomas, both at index procedure and cumulatively over the individual's lifetime. Patients with one or two small tubular adenomas removed do not have a significantly increased metachronous colorectal cancer risk<sup>[33]</sup>. In contrast, the presence of

one or more advanced adenomas predicts a higher rate of both any and advanced metachronous adenomas<sup>[25]</sup>. The risk of metachronous CRC increases with the number of advanced adenomas<sup>[24]</sup>. Large polyp size ( $\geq 10$  mm) and proximal location in the colon are independent predictors of further advanced neoplasia at follow-up<sup>[34]</sup>. The risk for metachronous advanced adenomas increases progressively with the number of adenomas at baseline examination: patients with only 1 adenoma have a risk of 9% while those with 5 or more adenomas have a 24% risk.

## BENEFIT OF COLONOSCOPY

Colonoscopic screening has been shown to be effective in reducing CRC incidence and mortality<sup>[27,35-38]</sup>.

This effect is *via* a number mechanisms. Firstly, the removal of pre-cancerous lesions, *i.e.*, adenomatous polyps, thereby interrupting the progression to carcinoma: preventing cancers. Secondly, detection of CRC at an earlier, pre-symptomatic stage with resultant increased likelihood of successful endoscopic or surgical treatment<sup>[27,39-41]</sup>.

The third mechanism, which may reduce CRC incidence and mortality, is surveillance colonoscopy. Risk stratification based upon index colonoscopy findings allows patients with polyps at higher risk of progression to cancer to be offered a further examination in the future<sup>[19,20,42]</sup>. The evidence for the potential benefits of surveillance will be discussed in detail later.

Patients diagnosed with CRC at an earlier stage have significantly better prognosis than those diagnosed with more extensive disease. Of patients diagnosed with Dukes' A CRC, 93% will survive 5 years. Those diagnosed with modified Dukes' D cancer however, have a less than 7% chance of living a further 5 years.

Colonoscopy is considered to be the gold standard for adenoma detection and affords an opportunity for therapy, through polypectomy, as well as allowing histological diagnosis. Double-contrast barium enema and CT colonography (CTC) show poorer sensitivity compared to colonoscopy, particularly with respect to very small and flat polyps<sup>[43,44]</sup>. An optimally performed double-contrast barium enema and FIT (faecal immunohistochemical test) detect only half of adenomas of 5 mm or larger that are detected by colonoscopy<sup>[45]</sup>.

## LIMITATIONS OF COLONOSCOPY

However, there remain limitations to colonoscopic screening. Even colonoscopy does not allow detection of all adenomas. "Back-to-back" colonoscopies have indicated significant miss rates of 27% for small adenomas (< 5 mm) and 6% for adenomas of more than 10 mm diameter<sup>[46]</sup>. Studies performing both CTC and colonoscopy estimate that the colonoscopy miss

rate for polyps over 10 mm in size may be as high as 12%<sup>[47]</sup>. There are multiple factors likely to contribute to missed polyps at colonoscopy including quality of bowel preparation, and the training and experience of the colonoscopist. The time taken by colonoscopists during withdrawal of the colonoscope from the caecum is a powerful predictor of adenoma detection rate (ADR)<sup>[48]</sup>. Higher rates of interval cancers are seen in association with low ADR at screening colonoscopy<sup>[49,50]</sup>.

The protection afforded by colonoscopy is significantly greater in respect of distal CRC as compared to lesions of the proximal colon. There are a number of factors postulated to explain this differential: poorer right-sided bowel preparation, incomplete colonoscopy, anatomical factors impeding visibility, and potentially different biology of right-sided lesions, especially via the serrated pathway<sup>[35,51]</sup>.

Incomplete resection of adenomatous tissue is believed to be a substantial contributor to interval cancers. Rates of incomplete resection for diminutive polyps are 29% for conventional biopsy and 17% for hot biopsy<sup>[52,53]</sup>. Residual polyp tissue is more likely to remain after resection of sessile polyps and risk increases with polyp size. Rates of 17% for polyps of 10-20 mm and 7% for lesions of 5-9 mm have been quoted. There also appears to be a higher rate of incomplete resection for serrated lesions in comparison to conventional adenomas (31% and 7% respectively)<sup>[54]</sup>.

Missed lesions are likely to account for more than half of interval cancers diagnosed at 3 to 5 years after the index procedure<sup>[55]</sup>. Therefore, the quality of the index and subsequent colonoscopies is paramount in maximising the potential benefit of surveillance procedures. Quality of colonoscopy is directly associated with rates of interval CRC<sup>[50]</sup>.

## RATIONALE FOR SURVEILLANCE

The major CRC mortality risk reduction is achieved at index colonoscopy, *i.e.*, diagnosis of cancers at an earlier stage and removal of adenomas with the aim of reducing CRC incidence.

Individuals found to have colonic polyps are at increased risk of advanced neoplasia in the future<sup>[11,23,56,57]</sup>. This risk may be due to a number of mechanisms: (1) Missed lesions at the initial colonoscopy; (2) Incomplete removal of adenomatous tissue at initial colonoscopy; and (3) The individual's propensity to colonic neoplasia (either lifestyle factors, an inherent imbalance of cell proliferation, or a combination of these)<sup>[25,46,57-60]</sup>.

In view of the increased risk of CRC, it seems logical that this group may benefit from closer monitoring than the general population. There are two reasons to consider surveillance colonoscopy in patients found to have adenomas at the index procedure. Firstly, as discussed above, there may be missed lesions, particularly small polyps, which may be identified at a subsequent procedure. Secondly, after a time interval,

**Table 1 British Society of Gastroenterology guidelines 2010<sup>[79]</sup>, supported by the 2011 guidelines of The National Institute for Health and Care Excellence**

Risk of colorectal cancer or advanced adenomas ( $\geq 1$  cm as measured at endoscopy or high-grade dysplasia)  
 Patients with only one or two small ( $< 1$  cm) adenomas are at low risk, and need no colonoscopic surveillance or 5-yearly until one negative examination then cease surveillance. Recommendation grade: B  
 Patients with three or four small adenomas or at least one adenoma  $\geq 1$  cm are at intermediate risk and should be screened 3-yearly until two consecutive examinations are negative. Recommendation grade: B  
 If either of the following is detected at any single examination (at baseline or follow-up): five or more adenomas, or three or more adenomas at least one of which is  $\geq 1$  cm, the patient is at high risk and an extra examination should be undertaken at 12 mo before returning to 3-yearly surveillance. Recommendation grade: B  
 Patients can be offered surveillance until age 75 yr and thereafter continue depending on relative cancer risk and comorbidity. Colonoscopy is likely to be less successful and more risky at older ages. Further, the average lead time for progression of an adenoma to cancer is 10 yr which is of the same order as the average life expectancy of an individual aged 75 yr or older, suggesting that most will not benefit from surveillance. Recommendation grade: B  
 These guidelines are based on accurate detection of adenomas, otherwise risk status will be underestimated. Patients with a failed colonoscopy, for whatever reason, should undergo repeat colonoscopy or an alternative complete colonic examination. Recommendation grade: B  
 The site of large sessile adenomas removed piecemeal should be re-examined at 2-3 mo. Small areas of residual polyp can then be treated endoscopically, with a further check for complete eradication in 2-3 mo. India ink tattooing aids recognition of the polypectomy site at follow-up. If extensive residual polyp is seen, surgical resection needs to be considered, or alternatively referral to a colonoscopist with special expertise in advanced polypectomy techniques. If there is complete healing of the polypectomy site, then there should be a colonoscopy at 1 yr, to check for missed synchronous polyps, before returning to 3 yearly surveillance. Recommendation grade: B

**Table 2 American Gastroenterological Association 2012<sup>[80]</sup>**

Findings at index procedure	Suggested surveillance interval	Strength of evidence
No polyps/small ( $< 10$ mm) rectosigmoid hyperplastic	10 yr	Moderate
1-2 small ( $< 10$ mm) tubular adenomas	5-10 yr	Moderate
3-10 tubular adenomas	3 yr	Moderate
$> 10$ adenomas	$< 3$ yr	Moderate
One tubular adenoma $\geq 10$ mm	3 yr	High
One villous adenoma	3 yr	Moderate
Adenoma with high grade dysplasia (HGD)	3 yr	Moderate
Serrated lesions		
Sessile serrated polyp (SSP) $< 10$ mm with no dysplasia	5 yr	Low
SSP $\geq 10$ mm OR with dysplasia OR serrated adenoma	3 yr	Low
Serrated polyposis syndrome	1 yr	Moderate

new lesions may have developed.

Although the risk of developing further adenomas is known, no randomised study has directly assessed the effect of post-polypectomy surveillance on CRC incidence or mortality. The efficacy of surveillance has been assessed by retrospective epidemiological series indicating that patients not entered into a surveillance programme have three- to fourfold greater risk of CRC. However, the increased risk pertains to those found to have advanced adenomas at the index procedure. Individuals with non-advanced adenomas did not have significantly higher risk than the general population<sup>[23,60]</sup>.

It is established that individuals with previously identified adenomas have an increased risk of further adenomas at a follow-up examination. At 4 year interval, 35.5% of patients will again be found to have at least one adenoma, but only 8.6%-12% will have advanced neoplasia (either an advanced

adenoma or carcinoma) with 0.6% having carcinoma. Factors conferring higher risk of further adenomas at surveillance are age greater than 60 years, male sex, and the presence of more than one adenoma at the initial procedure. The finding of more than 2 adenomas at initial examination increases the risk of advanced neoplasia at follow-up examination<sup>[32,61]</sup>.

## STRATIFICATION

Reported prevalence of adenomas ranges from 15%-40%, with advancing age and male sex associated with increasing prevalence. However, rates of adenoma detection may be as high as 50% in the general population when using modern "high definition" endoscopes<sup>[62,63]</sup>. Therefore the number of patients who could potentially be offered surveillance colonoscopy is substantial.

To avoid unnecessary, or "low yield", surveillance colonoscopies, it is necessary to identify those individuals with increased risk of CRC. This can be achieved through a risk stratification approach, as adopted by all the major current clinical guidelines (Tables 1-3).

Current guidelines vary in their definition of each risk group. However, there is consensus that individuals with one or two adenomas possessing no advanced features are classified as "low risk". At the opposite end of the spectrum, it is agreed that finding high grade dysplasia or greater than 10 adenomas confers a "high risk".

Current guidelines' variability in recommendations is due to the lack of good quality evidence to support surveillance strategy.

United Kingdom guidelines do not take account of polyp architecture, while guidance in the United States and Europe classifies individuals with a villous adenoma as "high risk".



**Table 3** European Society of Gastrointestinal Endoscopy 2013<sup>[81]</sup>

The following recommendations for post-polypectomy endoscopic surveillance should be applied only after a high quality baseline colonoscopy with complete removal of all detected neoplastic lesions
In the low risk group (patients with 1-2 tubular adenomas < 10 mm with low grade dysplasia), the European Society of Gastrointestinal Endoscopy (ESGE) recommends participation in existing national screening programmes 10 yr after the index colonoscopy. If no screening programme is available, repetition of colonoscopy 10 yr after the index colonoscopy is recommended (strong recommendation, moderate quality evidence)
In the high risk group (patients with adenomas with villous architecture or high grade dysplasia or $\geq$ 10 mm in size, or $\geq$ 3 adenomas), the ESGE recommends surveillance colonoscopy 3 yr after the index colonoscopy (strong recommendation, moderate quality evidence). Patients with 10 or more adenomas should be referred for genetic counselling (strong recommendation, moderate quality evidence)
In the high risk group, if no high risk adenomas are detected at the first surveillance examination, the ESGE suggests a 5-yr interval before a second surveillance colonoscopy (weak recommendation, low quality evidence). If high risk adenomas are detected at first or subsequent surveillance examinations, a 3-yr repetition of surveillance colonoscopy is recommended (strong recommendation, low quality evidence)
The ESGE recommends that patients with serrated polyps < 10 mm in size with no dysplasia should be classified as low risk (weak recommendation, low quality evidence). The ESGE suggests that patients with large serrated polyps ( $\geq$ 10 mm) or those with dysplasia should be classified as high risk (weak recommendation, low quality evidence)
The ESGE recommends that the endoscopist is responsible for providing a written recommendation for the post-polypectomy surveillance schedule (strong recommendation, low quality evidence)

In a comparison of current United Kingdom and United States guidelines, it was found that following United Kingdom guidelines would better identify a group of patients at high risk of advanced neoplasia: those with  $\geq$  5 small adenomas or  $\geq$  3 adenomas including at least one of  $\geq$  10 mm. These patients would be offered a surveillance interval of 3 years according to United States guidelines or 1 year according to United Kingdom guidance. At one year follow-up, this group had an 18.6% risk of advanced neoplasia<sup>[64]</sup>.

Conversely, patients with 1 or 2 small adenomas would be classified as low risk by United Kingdom guidelines regardless of histology. This group could be at relatively high risk if histology revealed advanced adenomas (HGD or villous architecture) and as such would be advised 3 year surveillance under United States guidelines. The same group of patients could have been offered no surveillance by following United Kingdom guidelines, but have a 7.1% absolute risk of advanced neoplasia at 1 year<sup>[64]</sup>.

Current guidelines take account of findings at both the index and first surveillance colonoscopy in determining the second surveillance interval. This approach would be supported by a recent study showing that high risk features identified at either the index or first surveillance procedure increase the risk of advanced neoplasia at second surveillance<sup>[65]</sup>.

## SURVEILLANCE INTERVALS

### High risk

The evidence to support the use of surveillance applies predominantly to the "high risk" group. The incidence of advanced neoplasia and carcinoma in these individuals is significantly increased at follow-up, and CRC mortality is reduced by their surveillance<sup>[33,59,60]</sup>.

Data from the United Kingdom screening programme shows that in high risk individuals (by United Kingdom guidelines), the overall yield for advanced neoplasia at first surveillance (at 12 mo) was 6.6%,

with a yield of 0.8% for CRC. These findings would support the current strategy of 12 mo surveillance in this group<sup>[66]</sup>. The same study found that villous architecture and a right-sided adenoma at the index procedure were associated with an increased risk of finding advanced neoplasia at 1 year follow-up. Therefore within the high risk group, there are other factors which could be used to further inform the appropriate surveillance interval for an individual.

Current United States guidelines classify patients with > 10 adenomas as highest risk. However, as only 0.1% of screening patients fall into this category, its clinical utility is limited.

### Low risk

Within the low risk group, it is known that the absolute risk of advanced neoplasia at follow-up is low. Current guidelines are based on evidence that this group carries no increased risk of CRC compared to the general population<sup>[23,25]</sup>. A recent meta-analysis suggested individuals in the low risk group at the index procedure have a higher risk of advanced neoplasia at follow-up compared to those found to have no adenoma<sup>[67]</sup>. However, the absolute risk in both groups remains very low.

On the basis that the low risk group carry a risk of CRC equivalent to the general population, the guidelines advise surveillance at the interval prescribed by the relevant screening programme, *i.e.*, effectively advising no increased surveillance over that of the general population. The United Kingdom guidelines allow for deviation from this rule in that the low risk group may be offered no surveillance or a further procedure at 5 years. Of note, the United Kingdom NHS Bowel Cancer Screening Programme (BCSP), while following United Kingdom guidelines (BSG, 2010 and NICE, 2011), offers no surveillance in this group.

Recent data from Norway suggest a significant reduction in CRC mortality at 7.7 years in "low risk" patients after a single screening examination<sup>[68]</sup>. However, the definition of "low risk" used in this study

differs from that used in current guidelines as the study authors used cancer registry data and so did not have access to details of polyp size or number. Therefore, all patients with “multiple” polyps or with histology showing either villous architecture or high-grade dysplasia were classified as “high-risk”. This definition makes comparison with other studies difficult.

### **Intermediate risk**

Current guidelines differ most in recommendations for individuals with intermediate risk. It is in this group of patients that the benefit of surveillance is most uncertain.

Patients with 3 or 4 diminutive adenomas at index colonoscopy would be offered a surveillance procedure at 3 years according to United Kingdom, European, and United States guidelines. However, there is little evidence that this group of patients carries any significantly increased CRC risk compared to the general population.

There is evidence for the increased risk of identifying further adenomas at first surveillance in patients classified as intermediate risk at index procedure. However, the relative risk varies within this group of individuals dependent upon factors such as polyp size, patient age, and the presence of advanced adenoma at the index procedure, *i.e.*, with the varying definition of intermediate risk<sup>[69]</sup>. Evidence for an effect of surveillance on CRC incidence and mortality is lacking.

### **Serrated lesions**

American and European guidelines include serrated polyps in their recommendations, which are not specifically dealt with in United Kingdom guidelines.

Serrated polyps are known to be more challenging to identify at colonoscopy and their predilection for the proximal colon is thought in part to explain the relatively lower protective effect of colonoscopy on incidence of right-sided CRCs<sup>[10]</sup>.

Significant variability in detection of these lesions by endoscopists and their classification by pathologists has caused evidence on their natural history and risk profile to be lacking. However, further study and increased awareness of these lesions is likely to lead to further recommendations for surveillance in individuals found to have serrated polyps.

---

## **DISADVANTAGES AND LIMITATIONS OF SURVEILLANCE**

At present, surveillance procedures account for 20%-30% of capacity in endoscopy departments: approximately the same proportion as primary screening procedures<sup>[70-73]</sup>. It is likely that demand for surveillance procedures will increase in line with more widespread implementation of screening programmes,

rising adenoma detection rates associated with modern endoscopes and rising quality standards, and the increased recognition and surveillance of serrated lesions.

While colonoscopy is a generally safe procedure, there is a risk of major complications<sup>[74]</sup>. As such, the decision to proceed with surveillance colonoscopy must be informed by both the risk of CRC and the risk of a complication related to the procedure. Additionally, even an uncomplicated colonoscopy may represent considerable burden on the patient, who undergoes bowel preparation, time off work, and potential discomfort during the procedure. Fear of pain during the procedure is known to reduce the uptake of screening colonoscopy<sup>[75,76]</sup>. For surveillance programmes to be effective, uptake must be maximised. By definition, individuals invited for surveillance already have personal experience of colonoscopy. This experience is likely to inform the individual's decision on whether to undergo a surveillance procedure, highlighting the importance of patient experience during colonoscopy.

---

## **WHEN TO STOP SURVEILLANCE**

The decision to discontinue surveillance is guided in current literature only on the criterion of the patient's chronological age<sup>[77]</sup>. It is known that rates of complications and post-procedure hospital admission are increased with advancing age and multi-morbidity. Advancing age also reduces the potential survival benefit in surveillance: as progression from adenoma to carcinoma is likely to take around 10 years, patients with a life expectancy of a similar or shorter time have little chance of benefit from a surveillance colonoscopy.

However, the use of chronological age alone is an over-simplification of the decision to discontinue surveillance: a decision which must balance the relative risks for the individual.

Patients found at their initial procedure to have an advanced adenoma, have a CRC risk similar to that of the general population after just one surveillance follow-up colonoscopy<sup>[23,59]</sup>. Further study is needed to identify more detailed criteria to guide the decision on continued surveillance.

---

## **ADHERENCE**

There is strong evidence that adherence to current guidelines by physicians is highly variable<sup>[78]</sup>. Some surveillance procedures are performed earlier than advised, some late, and some not performed at all. Clinical guidelines are only a guide to clinicians and many will choose to advise a different approach for an individual patient.

Also, patients may choose not to be subjected to surveillance procedures for multiple reasons including their experience of colonoscopy and the perceived benefits of surveillance. The subject of patient choice

Table 4 Adenoma surveillance

Findings at index procedure	Suggested initial surveillance interval
No adenomas	No surveillance
1-2 adenomas with no advanced neoplasia	No surveillance
3-4 adenomas with no advanced neoplasia	3 yr
≥ 3 adenomas and advanced neoplasia	1 yr
≥ 5 adenomas	1 yr

in surveillance is an area requiring further study.

## FURTHER STUDY

As discussed in the introduction to this paper, progression from adenoma to cancer usually occurs over many years. As such, the benefits of surveillance of colonic adenomas in reducing morbidity and mortality can only be realised over the long term. The introduction of surveillance programmes has become widespread only in recent years, so far limiting the available data on long-term follow-up. The known increased risk of CRC in patients found to have adenomas would make a randomised trial comparing surveillance to no surveillance unethical. Therefore, further study of the data from the era of widespread adenoma surveillance is needed to better inform future practice.

Current guidelines base recommendations on data collected prior to the widespread implementation of population screening programmes and prior to the use of robust quality metrics in colonoscopy. These factors may significantly alter the population classified within each risk group and so have a major impact on the outcomes of each group. More contemporary data from the era of high quality colonoscopy and population screening may allow more accurate risk stratification to better utilise limited colonoscopy resources in the future.

### Future of adenoma surveillance

The Table 4 summarises suggested surveillance intervals based on current knowledge on risk stratification by polyp factors.

Polyp factors may be used, as in current guidelines, to determine surveillance interval. However, including other patient factors in this assessment may allow more accurate risk stratification. Possible factors include age, sex, family history of colorectal cancer, smoking status, or obesity.

Additionally, this combination of polyp and patient factors may further inform the decision on whether to continue with any further surveillance after the first surveillance procedure, as it is the first surveillance procedure that has greatest effect in reducing the future risk in the highest risk patients.

## CONCLUSION

Internationally, increasing numbers of patients are embarking upon a course of surveillance colonoscopies due to the polyps discovered at the time of a previous examination. Each colonoscopy involves the burden of bowel preparation, potential anxiety and discomfort, and risk of complication for the patient. In many health settings, colonoscopy is a finite resource and so must be recommended only with a strong indication.

It is believed that individuals with non-advanced adenomas have no significantly increased risk of colorectal cancer compared to the general population. In addition, patients found at their initial procedure to have an advanced adenoma, have a CRC risk similar to that of the general population after just one surveillance follow-up colonoscopy<sup>[23,59]</sup>.

As shown in this review, there is some retrospective evidence to support surveillance procedures in patients at the highest risk of CRC. For those at lower risk, further evidence is needed to better stratify risk and so inform discussions between the individual and their clinician on whether surveillance colonoscopy is appropriate.

## REFERENCES

- 1 **Cancer Research UK.** Bowel Cancer Statistics. Cancer Research UK, 2015. Accessed January 2016. Available from: URL: <http://www.cancerresearchuk.org/health-professional/bowel-cancer-incidence-statistics>
- 2 **American Cancer Society.** Colorectal Cancer Facts & Figures 2014-2016. Atlanta: American Cancer Society, 2014. Available from: URL: <http://www.cancer.org/>
- 3 **Vogelstein B, Fearon ER, Hamilton SR, Kern SE, Preisinger AC, Leppert M, Nakamura Y, White R, Smits AM, Bos JL.** Genetic alterations during colorectal-tumor development. *N Engl J Med* 1988; **319**: 525-532 [PMID: 2841597 DOI: 10.1056/NEJM198809013190901]
- 4 **Nowell PC.** Mechanisms of tumor progression. *Cancer Res* 1986; **46**: 2203-2207 [PMID: 3516380]
- 5 **Risio M.** The natural history of adenomas. *Best Pract Res Clin Gastroenterol* 2010; **24**: 271-280 [PMID: 20510828 DOI: 10.1016/j.bpg.2010.04.005]
- 6 **Morson BC.** The evolution of colorectal carcinoma. *Clin Radiol* 1984; **35**: 425-431 [PMID: 6499378 DOI: 10.1016/S0009-9260(84)80033-1]
- 7 **Muto T, Bussey HJ, Morson BC.** The evolution of cancer of the colon and rectum. *Cancer* 1975; **36**: 2251-2270 [PMID: 1203876 DOI: 10.1002/cncr.2820360944]
- 8 **Morson BC.** Genesis of colorectal cancer. *Clin Gastroenterol* 1976; **5**: 505-525 [PMID: 1022372]
- 9 **Leggett B, Whitehall V.** Role of the serrated pathway in colorectal cancer pathogenesis. *Gastroenterology* 2010; **138**: 2088-2100 [PMID: 20420948 DOI: 10.1053/j.gastro.2009.12.066]
- 10 **East JE, Vieth M, Rex DK.** Serrated lesions in colorectal cancer screening: detection, resection, pathology and surveillance. *Gut* 2015; **64**: 991-1000 [PMID: 25748647 DOI: 10.1136/gutjnl-2014-309041]
- 11 **Loeve F, Boer R, Zauber AG, Van Ballegooijen M, Van Oortmarssen GJ, Winawer SJ, Habbema JD.** National Polyp Study data: evidence for regression of adenomas. *Int J Cancer* 2004; **111**: 633-639 [PMID: 15239144 DOI: 10.1002/ijc.20277]
- 12 **Eide TJ.** Risk of colorectal cancer in adenoma-bearing individuals within a defined population. *Int J Cancer* 1986; **38**: 173-176 [PMID:

- 3733258]
- 13 **Hoff G**, Foerster A, Vatn MH, Saunar J, Larsen S. Epidemiology of polyps in the rectum and colon. Recovery and evaluation of unresected polyps 2 years after detection. *Scand J Gastroenterol* 1986; **21**: 853-862 [PMID: 3775252 DOI: 10.3109/00365528609011130]
  - 14 **Eide TJ**. Natural history of adenomas. *World J Surg* 1991; **15**: 3-6 [PMID: 1994603 DOI: 10.1007/BF01658952]
  - 15 **Stryker SJ**, Wolff BG, Culp CE, Libbe SD, Ilstrup DM, MacCarty RL. Natural history of untreated colonic polyps. *Gastroenterology* 1987; **93**: 1009-1013 [PMID: 3653628]
  - 16 **Rex DK**, Lehman GA, Hawes RH, Ulbright TM, Smith JJ. Screening colonoscopy in asymptomatic average-risk persons with negative fecal occult blood tests. *Gastroenterology* 1991; **100**: 64-67 [PMID: 1796931]
  - 17 **DiSario JA**, Foutch PG, Mai HD, Pardy K, Manne RK. Prevalence and malignant potential of colorectal polyps in asymptomatic, average-risk men. *Am J Gastroenterol* 1991; **86**: 941-945 [PMID: 1858757]
  - 18 **Leslie A**, Carey FA, Pratt NR, Steele RJ. The colorectal adenoma-carcinoma sequence. *Br J Surg* 2002; **89**: 845-860 [PMID: 12081733 DOI: 10.1046/j.1365-2168.2002.02120.x]
  - 19 **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**: 162-168 [PMID: 10900274 DOI: 10.1056/NEJM200007203430301]
  - 20 **Imperiale TF**, Wagner DR, Lin CY, Larkin GN, Rogge JD, Ransohoff DF. Risk of advanced proximal neoplasms in asymptomatic adults according to the distal colorectal findings. *N Engl J Med* 2000; **343**: 169-174 [PMID: 10900275 DOI: 10.1056/NEJM200007203430302]
  - 21 **Regula J**, Rupinski M, Kraszewska E, Polkowski M, Pachlewski J, Orłowska J, Nowacki MP, Butruk E. Colonoscopy in colorectal-cancer screening for detection of advanced neoplasia. *N Engl J Med* 2006; **355**: 1863-1872 [PMID: 17079760 DOI: 10.1056/NEJMoa054967]
  - 22 **Hassan C**, Pickhardt PJ, Kim DH, Di Giulio E, Zullo A, Laghi A, Repici A, Iafate F, Osborn J, Annibale B. Systematic review: distribution of advanced neoplasia according to polyp size at screening colonoscopy. *Aliment Pharmacol Ther* 2010; **31**: 210-217 [PMID: 19814745 DOI: 10.1111/j.1365-2036.2009.04160.x]
  - 23 **Cottet V**, Jooste V, Fournel I, Bouvier AM, Faivre J, Bonithon-Kopp C. Long-term risk of colorectal cancer after adenoma removal: a population-based cohort study. *Gut* 2012; **61**: 1180-1186 [PMID: 22110052 DOI: 10.1136/gutjnl-2011-300295]
  - 24 **Winawer SJ**, Zauber AG, O'Brien MJ, Ho MN, Gottlieb L, Sternberg SS, Wayne JD, Bond J, Schapiro M, Stewart ET. Randomized comparison of surveillance intervals after colonoscopic removal of newly diagnosed adenomatous polyps. The National Polyp Study Workgroup. *N Engl J Med* 1993; **328**: 901-906 [PMID: 8446136 DOI: 10.1056/nejm199304013281301]
  - 25 **Atkin WS**, Morson BC, Cuzick J. Long-term risk of colorectal cancer after excision of rectosigmoid adenomas. *N Engl J Med* 1992; **326**: 658-662 [PMID: 1736104 DOI: 10.1056/NEJM199203053261002]
  - 26 **Brenner H**, Hoffmeister M, Stegmaier C, Brenner G, Altenhofen L, Haug U. Risk of progression of advanced adenomas to colorectal cancer by age and sex: estimates based on 840,149 screening colonoscopies. *Gut* 2007; **56**: 1585-1589 [PMID: 17591622 DOI: 10.1136/gut.2007.122739]
  - 27 **Winawer SJ**, Zauber AG, Ho MN, O'Brien MJ, Gottlieb LS, Sternberg SS, Wayne JD, Schapiro M, Bond JH, Panish JF. Prevention of colorectal cancer by colonoscopic polypectomy. The National Polyp Study Workgroup. *N Engl J Med* 1993; **329**: 1977-1981 [PMID: 8247072 DOI: 10.1056/NEJM199312303292701]
  - 28 **Butterly LF**, Chase MP, Pohl H, Fiarman GS. Prevalence of clinically important histology in small adenomas. *Clin Gastroenterol Hepatol* 2006; **4**: 343-348 [PMID: 16527698 DOI: 10.1016/j.cgh.2005.12.021]
  - 29 **Lieberman D**, Moravec M, Holub J, Michaels L, Eisen G. Polyp size and advanced histology in patients undergoing colonoscopy screening: implications for CT colonography. *Gastroenterology* 2008; **135**: 1100-1105 [PMID: 18691580 DOI: 10.1053/j.gastro.2008.06.083]
  - 30 **O'Brien MJ**, Winawer SJ, Zauber AG, Gottlieb LS, Sternberg SS, Diaz B, Dickersin GR, Ewing S, Geller S, Kasimian D. The National Polyp Study. Patient and polyp characteristics associated with high-grade dysplasia in colorectal adenomas. *Gastroenterology* 1990; **98**: 371-379 [PMID: 2403953]
  - 31 **Konishi F**, Morson BC. Pathology of colorectal adenomas: a colonoscopic survey. *J Clin Pathol* 1982; **35**: 830-841 [PMID: 7107955 DOI: 10.1136/jcp.35.8.830]
  - 32 **Martínez ME**, Baron JA, Lieberman DA, Schatzkin A, Lanza E, Winawer SJ, Zauber AG, Jiang R, Ahnen DJ, Bond JH, Church TR, Robertson DJ, Smith-Warner SA, Jacobs ET, Alberts DS, Greenberg ER. A pooled analysis of advanced colorectal neoplasia diagnoses after colonoscopic polypectomy. *Gastroenterology* 2009; **136**: 832-841 [PMID: 19171141 DOI: 10.1053/j.gastro.2008.12.007]
  - 33 **Lieberman DA**, Weiss DG, Harford WV, Ahnen DJ, Provenzale D, Sontag SJ, Schnell TG, Chejfec G, Campbell DR, Kidao J, Bond JH, Nelson DB, Triadafilopoulos G, Ramirez FC, Collins JF, Johnston TK, McQuaid KR, Garewal H, Sampliner RE, Esquivel R, Robertson D. Five-year colon surveillance after screening colonoscopy. *Gastroenterology* 2007; **133**: 1077-1085 [PMID: 17698067 DOI: 10.1053/j.gastro.2007.07.006]
  - 34 **Martínez ME**, Sampliner R, Marshall JR, Bhattacharyya AK, Reid ME, Alberts DS. Adenoma characteristics as risk factors for recurrence of advanced adenomas. *Gastroenterology* 2001; **120**: 1077-1083 [PMID: 11266371 DOI: 10.1053/gast.2001.0050101083]
  - 35 **Baxter NN**, Goldwasser MA, Paszat LF, Saskin R, Urbach DR, Rabeneck L. Association of colonoscopy and death from colorectal cancer. *Ann Intern Med* 2009; **150**: 1-8 [PMID: 19075198 DOI: 10.7326/0003-4819-150-1-200901060-00306]
  - 36 **Hewitson P**, Glasziou P, Irwig L, Towler B, Watson E. Screening for colorectal cancer using the faecal occult blood test, Hemocult. *Cochrane Database Syst Rev* 2007; **(1)**: CD001216 [PMID: 17253456 DOI: 10.1002/14651858.CD001216.pub2]
  - 37 **Atkin WS**, Edwards R, Kralj-Hans I, Wooldrage K, Hart AR, Northover JM, Parkin DM, Wardle J, Duffy SW, Cuzick J. Once-only flexible sigmoidoscopy screening in prevention of colorectal cancer: a multicentre randomised controlled trial. *Lancet* 2010; **375**: 1624-1633 [PMID: 20430429 DOI: 10.1016/S0140-6736(10)60551-X]
  - 38 **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 [PMID: 24922745 DOI: 10.1136/bmj.g2467]
  - 39 **Atkin W**, Kralj-Hans I, Wardle J, Duffy S. Colorectal cancer screening. Randomised trials of flexible sigmoidoscopy. *BMJ* 2010; **341**: c4618 [PMID: 20736284 DOI: 10.1136/bmj.c4618]
  - 40 **Kahi CJ**, Imperiale TF, Juliar BE, Rex DK. Effect of screening colonoscopy on colorectal cancer incidence and mortality. *Clin Gastroenterol Hepatol* 2009; **7**: 770-775; quiz 711 [PMID: 19268269 DOI: 10.1016/j.cgh.2008.12.030]
  - 41 **Segnan N**, Armaroli P, Bonelli L, Risio M, Sciallero S, Zappa M, Andreoni B, Arrigoni A, Bisanti L, Casella C, Crosta C, Falcini F, Ferrero F, Giacomini A, Giuliani O, Santarelli A, Visioli CB, Zanetti R, Atkin WS, Senore C. Once-only sigmoidoscopy in colorectal cancer screening: follow-up findings of the Italian Randomized Controlled Trial--SCORE. *J Natl Cancer Inst* 2011; **103**: 1310-1322 [PMID: 21852264 DOI: 10.1093/jnci/djr284]
  - 42 **Bretthauer M**, Kalager M. Colonoscopy as a triage screening test. *N Engl J Med* 2012; **366**: 759-760 [PMID: 22356330 DOI: 10.1056/NEJMe1114639]
  - 43 **Waye JD**. What is a gold standard for colon polyps? *Gastroenterology* 1997; **112**: 292-294 [PMID: 8978372 DOI: 10.1016/S0016-5085(97)70247-6]
  - 44 **Winawer SJ**, Stewart ET, Zauber AG, Bond JH, Ansel H, Wayne



- JD, Hall D, Hamlin JA, Schapiro M, O'Brien MJ, Sternberg SS, Gottlieb LS. A comparison of colonoscopy and double-contrast barium enema for surveillance after polypectomy. National Polyp Study Work Group. *N Engl J Med* 2000; **342**: 1766-1772 [PMID: 10852998 DOI: 10.1056/NEJM200006153422401]
- 45 **Imperiale TF**, Ransohoff DF, Itzkowitz SH, Levin TR, Lavin P, Lidgard GP, Ahlquist DA, Berger BM. Multitarget stool DNA testing for colorectal-cancer screening. *N Engl J Med* 2014; **370**: 1287-1297 [PMID: 24645800 DOI: 10.1056/NEJMoa1311194]
- 46 **Rex DK**, Cutler CS, Lemmel GT, Rahmani EY, Clark DW, Helper DJ, Lehman GA, Mark DG. Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies. *Gastroenterology* 1997; **112**: 24-28 [PMID: 8978338 DOI: 10.1016/S0016-5085(97)70214-2]
- 47 **Pickhardt PJ**, Choi JR, Hwang I, Butler JA, Puckett ML, Hildebrandt HA, Wong RK, Nugent PA, Mysliwiec PA, Schindler WR. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. *N Engl J Med* 2003; **349**: 2191-2200 [PMID: 14657426 DOI: 10.1056/NEJMoa031618]
- 48 **Barclay RL**, Vicari JJ, Doughty AS, Johanson JF, Greenlaw RL. Colonoscopic withdrawal times and adenoma detection during screening colonoscopy. *N Engl J Med* 2006; **355**: 2533-2541 [PMID: 17167136 DOI: 10.1056/NEJMoa055498]
- 49 **Kaminski MF**, Regula J, Kraszewska E, Polkowski M, Wojciechowska U, Didkowska J, Zwierko M, Rupinski M, Nowacki MP, Butruk E. Quality indicators for colonoscopy and the risk of interval cancer. *N Engl J Med* 2010; **362**: 1795-1803 [PMID: 20463339 DOI: 10.1056/NEJMoa0907667]
- 50 **Corley DA**, Jensen CD, Marks AR, Zhao WK, Lee JK, Doubeni CA, Zauber AG, de Boer J, Fireman BH, Schottinger JE, Quinn VP, Ghai NR, Levin TR, Quesenberry CP. Adenoma detection rate and risk of colorectal cancer and death. *N Engl J Med* 2014; **370**: 1298-1306 [PMID: 24693890 DOI: 10.1056/NEJMoa1309086]
- 51 **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 [PMID: 20042716 DOI: 10.1093/jnci/djp436]
- 52 **Peluso F**, Goldner F. Follow-up of hot biopsy forceps treatment of diminutive colonic polyps. *Gastrointest Endosc* 1991; **37**: 604-606 [PMID: 1756918 DOI: 10.1016/S0016-5107(91)70863-8]
- 53 **Woods A**, Sanowski RA, Wadas DD, Manne RK, Friess SW. Eradication of diminutive polyps: a prospective evaluation of bipolar coagulation versus conventional biopsy removal. *Gastrointest Endosc* 1989; **35**: 536-540 [PMID: 2689263 DOI: 10.1016/S0016-5107(89)72906-0]
- 54 **Pohl H**, Srivastava A, Bensen SP, Anderson P, Rothstein RI, Gordon SR, Levy LC, Toor A, Mackenzie TA, Rosch T, Robertson DJ. Incomplete polyp resection during colonoscopy—results of the complete adenoma resection (CARE) study. *Gastroenterology* 2013; **144**: 74-80.e1 [PMID: 23022496 DOI: 10.1053/j.gastro.2012.09.043]
- 55 **Robertson DJ**, Lieberman DA, Winawer SJ, Ahnen DJ, Baron JA, Schatzkin A, Cross AJ, Zauber AG, Church TR, Lance P, Greenberg ER, Martinez ME. Colorectal cancers soon after colonoscopy: a pooled multicohort analysis. *Gut* 2014; **63**: 949-956 [PMID: 23793224 DOI: 10.1136/gutjnl-2012-303796]
- 56 **Yamaji Y**, Mitsushima T, Ikuma H, Watabe H, Okamoto M, Kawabe T, Wada R, Doi H, Omata M. Incidence and recurrence rates of colorectal adenomas estimated by annually repeated colonoscopies on asymptomatic Japanese. *Gut* 2004; **53**: 568-572 [PMID: 15016753 DOI: 10.1136/gut.2003.026112]
- 57 **Robertson DJ**, Greenberg ER, Beach M, Sandler RS, Ahnen D, Haile RW, Burke CA, Snover DC, Bresalier RS, McKeown-Eyssen G, Mandel JS, Bond JH, Van Stolk RU, Summers RW, Rothstein R, Church TR, Cole BF, Byers T, Mott L, Baron JA. Colorectal cancer in patients under dense colonoscopic surveillance. *Gastroenterology* 2005; **129**: 34-41 [PMID: 16012932 DOI: 10.1053/j.gastro.2005.05.012]
- 58 **Anti M**, Armuzzi A, Morini S, Iacone E, Pignataro G, Coco C, Lorenzetti R, Paolucci M, Covino M, Gasbarrini A, Vecchio F, Gasbarrini G. Severe imbalance of cell proliferation and apoptosis in the left colon and in the rectosigmoid tract in subjects with a history of large adenomas. *Gut* 2001; **48**: 238-246 [PMID: 11156647 DOI: 10.1136/gut.48.2.238]
- 59 **Brenner H**, Chang-Claude J, Rickert A, Seiler CM, Hoffmeister M. Risk of colorectal cancer after detection and removal of adenomas at colonoscopy: population-based case-control study. *J Clin Oncol* 2012; **30**: 2969-2976 [PMID: 22826281 DOI: 10.1200/JCO.2011.41.3377]
- 60 **Brenner H**, Chang-Claude J, Jansen L, Seiler CM, Hoffmeister M. Role of colonoscopy and polyp characteristics in colorectal cancer after colonoscopic polyp detection: a population-based case-control study. *Ann Intern Med* 2012; **157**: 225-232 [PMID: 22910933 DOI: 10.7326/0003-4819-157-4-201208210-00002]
- 61 **Jørgensen OD**, Kronborg O, Fenger C. A randomized surveillance study of patients with pedunculated and small sessile tubular and tubulovillous adenomas. The Funen Adenoma Follow-up Study. *Scand J Gastroenterol* 1995; **30**: 686-692 [PMID: 7481533 DOI: 10.3109/00365529509096314]
- 62 **Gupta N**, Bansal A, Rao D, Early DS, Jonnalagadda S, Wani SB, Edmundowicz SA, Sharma P, Rastogi A. Prevalence of advanced histological features in diminutive and small colon polyps. *Gastrointest Endosc* 2012; **75**: 1022-1030 [PMID: 22405698 DOI: 10.1016/j.gie.2012.01.020]
- 63 **Kahi CJ**, Hewett DG, Norton DL, Eckert GJ, Rex DK. Prevalence and variable detection of proximal colon serrated polyps during screening colonoscopy. *Clin Gastroenterol Hepatol* 2011; **9**: 42-46 [PMID: 20888435 DOI: 10.1016/j.cgh.2010.09.013]
- 64 **Martinez ME**, Thompson P, Messer K, Ashbeck EL, Lieberman DA, Baron JA, Ahnen DJ, Robertson DJ, Jacobs ET, Greenberg ER, Cross AJ, Atkin W. One-year risk for advanced colorectal neoplasia: U.S. versus U.K. risk-stratification guidelines. *Ann Intern Med* 2012; **157**: 856-864 [PMID: 23247939 DOI: 10.7326/003-4819-157-12-201212180-00005]
- 65 **Laish I**, Blechman I, Feingelernt H, Konikoff FM. Yield of second surveillance colonoscopy to predict adenomas with high-risk characteristics. *Dig Liver Dis* 2015; **47**: 805-810 [PMID: 26048253 DOI: 10.1016/j.dld.2015.05.005]
- 66 **Lee TJ**, Nickerson C, Goddard AF, Rees CJ, McNally RJ, Rutter MD. Outcome of 12-month surveillance colonoscopy in high-risk patients in the National Health Service Bowel Cancer Screening Programme. *Colorectal Dis* 2013; **15**: e435-e442 [PMID: 23663559 DOI: 10.1111/codi.12278]
- 67 **Hassan C**, Gimeno-García A, Kalager M, Spada C, Zullo A, Costamagna G, Senore C, Rex DK, Quintero E. Systematic review with meta-analysis: the incidence of advanced neoplasia after polypectomy in patients with and without low-risk adenomas. *Aliment Pharmacol Ther* 2014; **39**: 905-912 [PMID: 24593121 DOI: 10.1111/apt.12682]
- 68 **Løberg M**, Kalager M, Holme Ø, Hoff G, Adami HO, Bretthauer M. Long-term colorectal-cancer mortality after adenoma removal. *N Engl J Med* 2014; **371**: 799-807 [PMID: 25162886 DOI: 10.1056/NEJMoa1315870]
- 69 **de Jonge V**, Sint Nicolaas J, van Leerdam ME, Kuipers EJ, Veldhuyzen van Zanten SJ. Systematic literature review and pooled analyses of risk factors for finding adenomas at surveillance colonoscopy. *Endoscopy* 2011; **43**: 560-572 [PMID: 21437854 DOI: 10.1055/s-0030-1256306]
- 70 **Radaelli F**, Paggi S, Bortoli A, De Pretis G. Overutilization of post-polypectomy surveillance colonoscopy in clinical practice: a prospective, multicentre study. *Dig Liver Dis* 2012; **44**: 748-753 [PMID: 22627070 DOI: 10.1016/j.dld.2012.04.015]
- 71 **Rex DK**, Overhiser AJ, Chen SC, Cummings OW, Ulbright TM. Estimation of impact of American College of Radiology recommendations on CT colonography reporting for resection of high-risk adenoma findings. *Am J Gastroenterol* 2009; **104**: 149-153 [PMID: 19098863 DOI: 10.1038/ajg.2008.35]
- 72 **Lieberman DA**, Williams JL, Holub JL, Morris CD, Logan JR, Eisen GM, Carney P. Colonoscopy utilization and outcomes 2000 to 2011. *Gastrointest Endosc* 2014; **80**: 133-143 [PMID: 24565067 DOI: 10.1016/j.gie.2014.01.014]

- 73 **Petruzzello L**, Hassan C, Alvaro D, Kohn A, Rossi Z, Zullo A, Cesaro P, Annibale B, Barca A, Di Giulio E, Giorgi Rossi P, Grasso E, Ridola L, Spada C, Costamagna G. Appropriateness of the indication for colonoscopy: is the endoscopist the ‘gold standard’? *J Clin Gastroenterol* 2012; **46**: 590-594 [PMID: 22178958 DOI: 10.1097/MCG.0b013e3182370b7b]
- 74 **Levin TR**, Zhao W, Conell C, Seeff LC, Manninen DL, Shapiro JA, Schulman J. Complications of colonoscopy in an integrated health care delivery system. *Ann Intern Med* 2006; **145**: 880-886 [PMID: 17179057 DOI: 10.7326/0003-4819-145-12-200612190-00004]
- 75 **Subramanian S**, Liangpunsakul S, Rex DK. Preprocedure patient values regarding sedation for colonoscopy. *J Clin Gastroenterol* 2005; **39**: 516-519 [PMID: 15942439 DOI: 10.1097/01.mcg.0000165667.79530.44]
- 76 **Denberg TD**, Melhado TV, Coombes JM, Beaty BL, Berman K, Byers TE, Marcus AC, Steiner JF, Ahnen DJ. Predictors of nonadherence to screening colonoscopy. *J Gen Intern Med* 2005; **20**: 989-995 [PMID: 16307622 DOI: 10.1111/j.1525-1497.2005.00164.x]
- 77 **Zauber AG**, Lansdorp-Vogelaar I, Knudsen AB, Wilschut J, van Ballegooijen M, Kuntz KM. Evaluating Test Strategies for Colorectal Cancer Screening-Age to Begin, Age to Stop, and Timing of Screening Intervals: A Decision Analysis of Colorectal Cancer Screening for the U.S. Preventive Services Task Force from the Cancer Intervention and Surveillance Modeling Network (CISNET). Rockville (MD), 2009. Available from: URL: <http://www.rockvillemd.gov/>
- 78 **Shah TU**, Voils CI, McNeil R, Wu R, Fisher DA. Understanding gastroenterologist adherence to polyp surveillance guidelines. *Am J Gastroenterol* 2012; **107**: 1283-1287 [PMID: 22951869 DOI: 10.1038/ajg.2012.59]
- 79 **Cairns SR**, Scholefield JH, Steele RJ, Dunlop MG, Thomas HJ, Evans GD, Eaden JA, Rutter MD, Atkin WP, Saunders BP, Lucassen A, Jenkins P, Fairclough PD, Woodhouse CR. Guidelines for colorectal cancer screening and surveillance in moderate and high risk groups (update from 2002). *Gut* 2010; **59**: 666-689 [PMID: 20427401 DOI: 10.1136/gut.2009.179804]
- 80 **Lieberman DA**, Rex DK, Winawer SJ, Giardiello FM, Johnson DA, Levin TR. Guidelines for colonoscopy surveillance after screening and polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology* 2012; **143**: 844-857 [PMID: 22763141 DOI: 10.1053/j.gastro.2012.06.001]
- 81 **Hassan C**, Quintero E, Dumonceau JM, Regula J, Brandão C, Chaussade S, Dekker E, Dimis-Ribeiro M, Ferlitsch M, Gimeno-García A, Hazewinkel Y, Jover R, Kalager M, Loberg M, Pox C, Rembacken B, Lieberman D. Post-polypectomy colonoscopy surveillance: European Society of Gastrointestinal Endoscopy (ESGE) Guideline. *Endoscopy* 2013; **45**: 842-851 [PMID: 24030244 DOI: 10.1055/s-0033-1344548]

**P- Reviewer:** Meshikhes AWN, Tovey FI **S- Editor:** Ma YJ  
**L- Editor:** A **E- Editor:** Ma S





Published by **Baishideng Publishing Group Inc**

8226 Regency Drive, Pleasanton, CA 94588, USA

Telephone: +1-925-223-8242

Fax: +1-925-223-8243

E-mail: [bpgoffice@wjgnet.com](mailto:bpgoffice@wjgnet.com)

Help Desk: <http://www.wjgnet.com/esps/helpdesk.aspx>

<http://www.wjgnet.com>



ISSN 1007-9327



9 771007 932045