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## ORIGINAL ARTICLE

# Chronic loose stools following right-sided hemicolectomy for colon cancer and the association with bile acid malabsorption and small intestinal bacterial overgrowth

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## Abstract

**Aim:** Patients treated with right-sided hemicolectomy for colon cancer may suffer from long-term bowel dysfunction, including loose stools, urgency and faecal incontinence. The underlying causes are poorly understood. The aim of this case-control study was to investigate the aetiology of chronic loose stools among patients with right-sided hemicolectomy curatively operated for cancer.

**Method:** Cases with chronic loose stools (Bristol stool type 6–7) after right-sided hemicolectomy were compared with a control group of patients with right-sided hemicolectomy without loose stools. All patients underwent a selenium-75 homocholeic acid taurine (SeHCAT) scan to diagnose bile acid malabsorption (BAM) and a glucose breath test to diagnose small intestinal bacterial overgrowth (SIBO). Gastrointestinal transit time (GITT) was assessed with radiopaque markers. In a subgroup of patients, fibroblast growth factor 19 (FGF19) was measured in fasting blood. SIBO was treated with antibiotics and BAM was treated with bile acid sequestrants.

**Results:** We included 45 cases and 19 controls. In the case group, 82% ( $n = 36$ ) had BAM compared with 37% ( $n = 7$ ) in the control group,  $p < 0.001$ . SIBO was diagnosed in 73% ( $n = 33$ ) of cases with chronic loose stools and in 74% ( $n = 14$ ) of controls,  $p = 0.977$ . No association between BAM and SIBO was observed. GITT was similar in cases and controls. No difference in median FGF19 was observed between cases and controls ( $p = 0.894$ ), and no correlation was seen between FGF19 and SeHCAT retention ( $r_s 0.20$ ,  $p = 0.294$ ). Bowel symptoms among cases were reduced after treatment.

**Conclusion:** BAM and SIBO are common in patients having undergone right-sided hemicolectomy for cancer. Chronic loose stools were associated with BAM but not with SIBO.

The study is registered at [ClinicalTrials.gov](https://clinicaltrials.gov) (NCT number: NCT04003181).

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**KEYWORDS**

bile acid malabsorption, bowel dysfunction, colon cancer, right-sided hemicolectomy, small intestinal bacterial overgrowth

**INTRODUCTION**

The number of survivors after colorectal cancer has risen dramatically during the past decades. While functional complications to surgery for rectal cancer have received much attention, rather less attention has been paid to bowel function after surgery for colon cancer. Recent studies have shown that patients having undergone sigmoid resection suffer mainly from straining to defaecate, obstructed defaecation and incomplete evacuation, while patients treated with right-sided hemicolectomy report frequent bowel movements, loose or liquid stools, faecal urgency, faecal incontinence and nocturnal defaecation [1–4]. Thus, loose stools, defined as type 6 and 7 on the Bristol Stool Chart (BSC) [5], are significantly more common among patients with right-sided hemicolectomy than among the background population [2]. However, the underlying pathophysiology has not been investigated.

Bile acid malabsorption (BAM) is a potential cause of loose stools after right-sided colon surgery. BAM can be categorised as type 1 (secondary to ileal dysfunction due to resection or inflammation), type 2 (primary/idiopathic BAM) and type 3 [secondary to other disorders such as coeliac disease, pancreatic dysfunction, cholecystectomy, small intestinal bacterial overgrowth (SIBO), etc.] [6, 7]. While type 1 is true malabsorption, type 2 and 3 are characterised by an excessive amount of bile acids in the bowel. During the surgical procedure for right-sided colon cancer, the colon is resected at the transverse colon between the two branches of the middle colic artery and orally at the approximately distal 10 cm of the terminal ileum including the ileocaecal valve. In an extended right-sided hemicolectomy, the colon is resected at the transverse colon between the left branch of the middle colic artery and the left colic artery. Studies of patients with Crohn's disease have shown that resection of the terminal ileum can cause BAM [7–9]. Compared to most small intestinal resections for Crohn's disease, only a small segment of the terminal ileum is resected during a right-sided hemicolectomy, and it is unknown to which extent such minor resections cause BAM. However, this is plausible as Phillips et al. showed that 51% of patients with colorectal cancer referred with loose stools had BAM diagnosed by selenium-75 homocholeic acid taurine (SeHCAT) scan [10].

Resection of the ileocaecal valve may lead to retrograde passage of colonic bacteria resulting in SIBO. The bacteria may induce brush border injury in the small intestine leading to malabsorption of carbohydrates, which results in loose stools [11]. Furthermore, excess of bacteria in the small bowel may also deconjugate bile acids and thereby induce BAM type 3 [11, 12].

The production of bile acids in the liver is regulated by fibroblast growth factor 19 (FGF19), which is produced in the terminal ileum in response to luminal bile acids. Thus, lack of FGF19, and thereby

**What does this paper add to the literature?**

Loose stools are shown to be common following right-sided hemicolectomy for colon cancer. The underlying pathophysiology is, however, unknown. This study contributes to important knowledge regarding the association of bile acid malabsorption, small intestinal bacterial overgrowth and loose stools following right-sided hemicolectomy for colon cancer. This makes targeted treatment possible.

hepatic overproduction of bile acids, may be another cause of BAM following ileal resection [13–15].

No studies have systematically investigated the frequency of BAM, SIBO and abnormal FGF19 levels in patients having undergone right-sided hemicolectomy. This is unfortunate since targeted treatment holds the potential to improve quality of life in many colon cancer survivors with chronic loose stools [16]. Our main hypothesis was that the prevalence of BAM was higher among patients with chronic loose stools than among those without loose stools after right-sided hemicolectomy for colon cancer. We further hypothesised that an association would exist between BAM and SIBO. Therefore, the aim of the present study was to investigate the frequency and associations of BAM, SIBO and chronic loose stools as well as the levels of FGF19 in cancer survivors having undergone right-sided hemicolectomy.

**METHOD****Study population**

Patients with a primary adenocarcinoma in the right side of the colon who had been treated with curatively intended right-sided or extended right-sided hemicolectomy ± adjuvant chemotherapy were eligible for inclusion between September 2017 and November 2020. All patients had undergone surgery at least 1 year prior to inclusion and all patients were living in the Central or North Denmark Regions. Adjuvant chemotherapy for colon cancer is standardised in Denmark, so all patients suitable for chemotherapy were offered fluorouracil and a few received combined treatment with fluorouracil and oxaliplatin. At their first visit, patients were categorised as cases or controls. A picture of the BSC [5] was shown to all patients, and loose stools was defined as type 6 (fluffy or mushy) and 7 (liquid) [5, 17]. Forty-five patients had chronic loose stools and were classified as cases. Based on type 3–4 on the BSC and their own assessment of a maintained normal bowel function after right-sided

hemicolectomy, the remaining 19 patients comprised the control group.

Cases were recruited by two sources. (1) The majority (56%) had previously participated in a questionnaire study [2], and they were contacted by mail, primarily electronically or by letter if electronic communication was not an option. Non-responders received up to two reminders. (2) The remaining cases (44%) were recruited through the Danish Cancer Society Centre for Research on Survivorship and Late Adverse Effects after Cancer in the Pelvic Organs at Aarhus University Hospital, Denmark, to which they had been referred due to their symptoms.

Control patients were recruited based on their previous participation in the questionnaire study [2]. The control patients were matched to cases based on gender and age.

Patients were excluded if they had undergone other major gastrointestinal, urological or gynaecological surgery in order to exclude bowel dysfunction due to surgery in the pelvis. Other exclusion criteria were radiation therapy, recurrence of colon cancer, permanent stoma or pregnancy.

## Investigations

All patients were systematically investigated (Figure 1). Blood tests and stool samples were obtained in order to screen for common causes of chronic loose stools, for example, lactose intolerance, coeliac disease, inflammatory bowel disease, thyroid disorder and pancreatic exocrine deficiency. Patients' daily medication was examined. To diagnose BAM, a SeHCAT scan was performed to determine the 7-day retention of a synthetic bile acid isotope. After oral ingestion of the radiolabelled isotope, retention levels were measured on day 1 and 7 with the use of a gamma camera equipped with high resolution collimator. Retention levels <15% were considered diagnostic for BAM, and borderline BAM was defined as retention of 15%–20% [7, 18–21]. The severity of BAM was categorised based on SeHCAT retention as severe (<5%), moderate ( $\geq 5\%$  to <10%) and mild ( $\geq 10\%$  to <15%) [20, 21]. Hydrogen and methane breath tests were performed to diagnose SIBO [22, 23]. An increase of  $\geq 10$  ppm of hydrogen or methane was considered diagnostic. Gastrointestinal transit time (GITT) was determined by the Gothenburg radiopaque marker method [24]. Serum-FGF19 was measured from blood samples during fasting and analysed with ELISA (Human FGF-19 Quantikine ELISA, cat. no. DF1900, R&D Systems, Inc.). As an add-on

Examinations
<ul style="list-style-type: none"> <li>• Blood tests and faeces samples</li> <li>• Selenium-75 homocholeic acid taurine (SeHCAT) scan</li> <li>• Hydrogen and methane breath test</li> <li>• Fibroblast growth factor 19 (FGF19)</li> <li>• Gastrointestinal transit time</li> </ul>

**FIGURE 1** Diagnostic tests

investigation, the blood sample was only performed in a subgroup of cases and controls.

## Treatment

Patients were treated following an algorithm, which has previously been published [16]. If patients had SIBO and matching symptoms such as loose stools and bloating, they were treated with antibiotics for 6–7 days. Ciprofloxacin was first-choice medication followed by rifaximin if symptom relief was insufficient. Breath tests were repeated after antibiotic treatment cessation. If patients had complete symptom relief after antibiotic treatment, a SeHCAT scan was repeated to determine whether they had BAM secondary to SIBO.

If symptoms remained after antibiotic treatment or if SIBO was not present at the beginning, cases with BAM were treated with bile acid sequestrants. Cholestyramine was first-choice medication, and the dosage was gradually titrated to achieve maximum effect with minimal side effects. If it was intolerable or had insufficient effect, colesevelam was prescribed. If symptoms did not improve satisfactorily, dietary intervention was offered as a supplement. Thus, guided by a specialised dietician, patients were introduced to a permanent fat-reduced diet.

## Ethics

All patients gave written informed consent before inclusion. The study was approved by the Committee on Health Research Ethics in the Central Denmark Region (journal no. 1-10-72-301-16) and registered in the Central Denmark Region's register of research projects (journal no. 1-16-02-137-17). This study has been written according to the STROBE recommendations.

## Statistical analysis

Data are presented as number (%) and median (range) or median (interquartile range [IQR]). The t-test or Mann-Whitney U test was used, where applicable, to compare numerical data from cases and controls. Chi square test was used for binary data. Spearman's rank coefficients were used to assess the relationship between FGF19 and SeHCAT retention. The Wilcoxon signed-rank test or the McNemar test was used to compare symptoms in cases at baseline and after treatment. Data were analysed using Stata statistical software version 16.1 (StataCorp LLC).

Based on the study by Phillips et al. [10], we expected 51% of cases to have BAM. With a specificity of the SeHCAT scan of 99% [25, 26], the likelihood of having a positive scan will be 1% among controls. With a power of 80% and a significance level of 5%, only 11 patients were required in each group. However, to narrow the confidence intervals, we aimed to include 50 cases and 20 controls.

## RESULTS

### Patients

In total, 45 patients with chronic loose stools and 19 asymptomatic control patients were included in the study. Patient characteristics are shown in [Table 1](#). The two groups were largely similar in terms of age, gender and type of surgery. Time since surgery was comparable among cases and controls,  $p = 0.292$ . Additionally, 43% of cases and 42% of controls were treated with adjuvant chemotherapy. Among the 45 cases with chronic loose stools, 41 (98%) suffered from faecal urgency, 26 (62%) from incontinence for liquid stool and 19 (44%) had  $\geq 4$  bowel movements per day ([Table 2](#)).

### Screening for common causes of loose stools

Two cases and three control patients had genetic disposition to lactose intolerance. In three cases, we observed faecal elastase below  $100 \mu\text{g/g}$ . Moreover, in four cases, we found faecal calprotectin  $>200 \text{mg/kg}$  despite normal colonoscopy. None of the participants were diagnosed with coeliac disease. Haemoglobin, ferritin and folate levels were normal in all participants. Patients continued in the study even though they had genetic predisposition to lactose intolerance or abnormal blood or stool samples because they had been asymptomatic until they were treated for their cancer.

### Tests of gastrointestinal function

Results of SeHCAT scans, breath tests for bacterial overgrowth, GITTs and FGF19 are shown in [Table 3](#). BAM (retention level  $<15\%$ ) was found in 36 (82%) patients with chronic loose stools and in 7 (37%) control patients,  $p < 0.001$ . Odds ratio for having BAM among cases compared with controls was 7.71 [95% CI: 2.31–25.78]. The majority of cases had severe BAM (retention  $<5\%$ ;  $n = 20$ ). Surprisingly, the majority of controls diagnosed with BAM also had severe BAM ( $n = 6$ ). The breath test was positive in 33 (73%) cases and 14 (74%) controls,  $p = 0.977$ . As illustrated in [Table 4](#), no association was seen between SeHCAT retention and results of the breath tests in either cases or controls. Median GITT was 1.0 days in cases and 1.2 days

in controls,  $p = 0.127$  ([Table 3](#)). FGF19 was measured in a subgroup of patients comprising 21 cases and nine controls. In cases, median FGF19 was  $90.7 \text{ pg/ml}$  (IQR 67.9–135.8  $\text{pg/ml}$ ) and in controls, median FGF19 was  $93.9 \text{ pg/ml}$  (IQR 78.1–115.0  $\text{pg/ml}$ ),  $p = 0.894$ . We found no correlation between FGF19 and SeHCAT retention ( $r_s$  0.20,  $p = 0.294$ ). Median FGF19 values in terms of severity of BAM are shown in [Table 5](#) and the association is illustrated in [Figure 2](#).

### Results from intervention against SIBO and BAM

All cases with both SIBO and BAM were treated with antibiotics before any other treatment. Among 33 patients with chronic loose stools treated with ciprofloxacin or rifaximin, 26 had a second breath test performed after treatment cessation. The breath test remained positive in 19 (73%) patients.

Six cases diagnosed with both BAM and SIBO had sufficient symptom relief after treatment with antibiotics and had no other treatment. Of these, five continued to have a positive breath test. In three cases, a SeHCAT scan was repeated following normalisation of bowel function after antibiotic treatment. Retention remained severely low ( $n = 2$ ) or showed borderline BAM ( $n = 1$ ).

Eight cases (18%) had normal SeHCAT retention and thus no BAM. Six of these cases were treated with antibiotics for SIBO. After treatment, three still had bowel dysfunction and a positive control breath test. They were treated with repeated rounds of antibiotics ( $n = 2$ ) or dietary intervention ( $n = 1$ ).

Twenty-six cases diagnosed with BAM were treated with cholestyramine, and 12 cases were also treated with colesevelam due to insufficient effect or discomfort from cholestyramine.

[Table 2](#) shows bowel function in cases before and after treatment with antibiotics, bile acid sequestrants and/or dietary intervention with a fat-reduced diet. Bristol stool type, defaecation frequency, urgency and incontinence were all improved.

## DISCUSSION

The present study provides detailed information about the causes of chronic loose stools in patients treated with right-sided hemicolectomy for cancer. The results are highly relevant for a large number

**TABLE 1** Patient characteristics

	Cases	Controls
Patients, $n$	45	19
Age, years, median (range)	71 (35–88)	72 (61–86)
Gender, female, $n$ (%)	25 (56)	9 (47)
Time since surgery, years, median (range)	3.8 (1.0–13.0)	5.9 (1.5–15.2)
Type of surgery		
Right-sided hemicolectomy, $n$ (%)	39 (87)	16 (84)
Extended right-sided hemicolectomy, $n$ (%)	6 (13)	3 (16)
Chemotherapy, $n$ (%)	19 (43)	8 (42)

**TABLE 2** Bowel symptoms in cases before and after treatment

Bowel symptoms	Before treatment	After treatment	p-value
Bristol stool scale			
Type 1	-	1 (2.3)	<0.001
Type 2	-	4 (9.3)	
Type 3	-	5 (11.6)	
Type 4	-	15 (34.9)	
Type 5	-	9 (20.9)	
Type 6	26 (61.9)	9 (20.9)	
Type 7	16 (38.1)	-	
Defaecation frequency			
<1 time per day	2 (4.7)	3 (7.0)	<0.001
1–3 times per day	22 (51.2)	35 (81.4)	
4–7 times per day	16 (37.2)	4 (9.3)	
>7 times per day	3 (7.0)	1 (2.3)	
Urgency			
Never	1 (2.4)	7 (16.3)	<0.001
<1 time per week	5 (11.9)	17 (39.5)	
≥1 time per week	36 (85.7)	19 (44.2)	
Incontinence, liquid stools			
Never	16 (38.1)	29 (67.4)	<0.001
Rarely	1 (2.4)	3 (7.0)	
Sometimes	11 (26.2)	8 (18.6)	
Weekly	10 (23.8)	3 (7.0)	
Daily	4 (9.5)	-	
Wears pad	12 (29.3)	8 (18.6)	0.125

Note: Data are presented as number (%).

of colon cancer survivors worldwide. Our main findings were that both BAM and SIBO were extremely common; BAM was diagnosed in 68% and SIBO in 73%. Chronic loose stools were strongly associated with BAM but not with SIBO. Hence, we find that BAM may be a main cause of chronic loose stools following right-sided hemicolectomy, while SIBO seems to be of lesser clinical importance. We found no association between FGF19 and chronic loose stools or between FGF19 and SeHCAT retention. This is interesting since low SeHCAT retention is known to correlate well with low FGF19, and several studies have found a reduced median FGF19 in patients with loose stools due to BAM [13, 14, 27, 28].

An association between right-sided hemicolectomy and BAM has been known since 1989 [29]. Later, Phillips et al. [10] reported that 51% of their patients with lower gastrointestinal cancer, who reported Bristol stool type 6 or 7, had BAM. Our data suggest that BAM after right-sided hemicolectomy is caused by lack of absorptive capacity in the terminal ileum (type 1 BAM) rather than being secondary to SIBO or impaired FGF19 production.

Bile acid diarrhoea is caused by excessive amounts of bile acids entering the colon. The condition often coexists with BAM, but it is not necessarily so. As illustrated in the present study, several

patients had BAM defined by SeHCAT without developing diarrhoea/loose stools. Disorders of bile acid production and circulation have been thoroughly described [15, 30], but much less is known about the effect of bile acids in the colon. Excess amounts of free bile acids in the colon may increase colonic motility, increase water secretion and decrease water absorption through the mucosa [30–32]. However, in the present study, we found no difference in GITT between patients with and without chronic loose stools. Surprisingly, 37% of our control group of patients without loose stools had BAM of whom 32% had severe BAM. This indicates that bile acid diarrhoea following right-sided hemicolectomy is not merely a disorder of transit, which calls for further studies of the effect of bile acids on colonic physiology.

The previous standard for diagnosing BAM was the <sup>14</sup>C glycocholate breath test combined with a 24-h collection of stools [33]. This technique is cumbersome and, in many centres, SeHCAT scan is used as a valid alternative [7, 13, 20]. Even though SeHCAT retention levels might vary slightly over time, the retention level is overall shown to remain stable over time in patients with chronic loose stools [34]. FGF19 regulates the production of bile acids in the liver [15], and the level of FGF19 in serum correlates with SeHCAT retention [13]. Thus, serum-FGF19 is suggested to be an effective and less expensive way of diagnosing BAM. However, FGF19 concentrations vary throughout the day as FGF19 responds rapidly to changes in bile acid concentrations in the ileum occurring after meals [35]. By comparison, SeHCAT retention reflects a 7-day period, which requires less standardisation of the test [13]. We found no association between FGF19 and SeHCAT retention in our patients with right-sided resected colon cancer. Hence, measurement of FGF19 might be of no use in this patient group. However, the subgroup of patients in the present study who underwent measurement of FGF19 was small and larger studies are necessary to determine the role of FGF19 in patients with right-sided hemicolectomy and chronic loose stools.

SeHCAT is not universally available, and some clinicians use the clinical response to bile acid sequestrants to diagnose BAM [36]. Low SeHCAT retention levels predict a good clinical response to bile acid sequestrants [20]. It is, however, unknown whether a clinical response to bile acid sequestrants is useful when diagnosing BAM. As BAM is a lifelong condition, we advocate having a firm diagnosis based on SeHCAT before initiating treatment [37]. In addition, many patients with BAM abandon treatment after a few years [38].

In 1978, Cosnes et al. [39] showed that removal of the ileocaecal valve may lead to malabsorption of, for example, fat and vitamin B12, probably due to retrograde passage of colonic bacteria. Since the ileocaecal valve is resected during a right-sided hemicolectomy, patients may develop SIBO [40]. SIBO may cause deconjugation of bile acids in the small bowel and thereby BAM [11]. Therefore, symptomatic patients with SIBO were treated with antibiotics before treatment with bile acid sequestrants, and a few patients achieved normalisation of their bowel function from antibiotic treatment alone. Only three patients had a repeated SeHCAT scan following eradication of SIBO. This is too

**TABLE 3** Results of diagnostic tests

	Cases	Controls	p-value
SeHCAT			
≥15%	8 (18.2)	12 (63.2)	<0.001
<15%	36 (81.8)	7 (36.8)	
Severity of BAM			
Mild (10%–14.9%)	7 (15.9)	–	0.020
Moderate (5%–9.9%)	9 (20.5)	1 (5.3)	
Severe (<5%)	20 (45.5)	6 (31.6)	
Breath test			
Negative	12 (26.7)	5 (26.3)	0.977
Positive	33 (73.3)	14 (73.7)	
GITT, median (IQR)	1.0 (0.6–1.6)	1.2 (0.7–2.6)	0.127
FGF19, pg/ml, median (IQR)	90.7 (67.9–135.8)	93.9 (78.1–115.0)	0.894

Note: Data are presented as number (%).

Abbreviations: BAM, bile acid malabsorption; FGF19, fibroblast growth factor 19. FGF19 was measured in 21 cases and nine controls; GITT, gastrointestinal transit time, in days; IQR, interquartile range; SeHCAT, selenium-75 homocholeic acid taurine. SeHCAT was missing in one case.

**TABLE 4** Association between SeHCAT retention and breath test

	Cases		Controls	
	SeHCAT ≥15%	SeHCAT <15%	SeHCAT ≥15%	SeHCAT <15%
Positive breath test	6 (75)	26 (72)	9 (75)	5 (71)
Negative breath test	2 (25)	10 (28)	3 (25)	2 (29)

Note: Data are presented as number (%).

Abbreviation: SeHCAT, selenium-75 homocholeic acid taurine. SeHCAT was missing in one case.

**TABLE 5** Association between SeHCAT retention and FGF19

SeHCAT retention	Median FGF19 (IQR; pg/ml)
<5%	78.1 (67.9–110.4)
5%–9.9%	62.6 (28.3–136.2)
10%–14.9%	76.4 (62.1–185.2)
>15%	115.0 (87.0–135.8)

Abbreviations: FGF19, fibroblast growth factor 19. FGF19 was measured in 21 cases and nine controls; IQR, interquartile range; SeHCAT, selenium-75 homocholeic acid taurine.

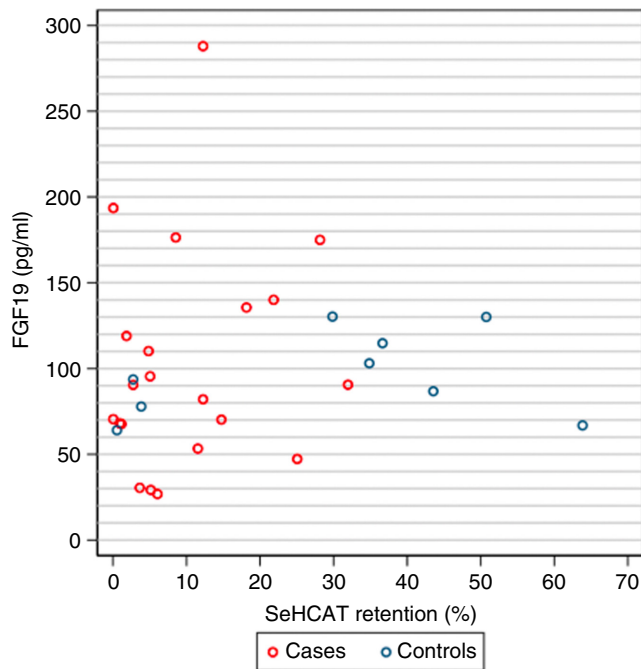
few to draw any conclusions but the fact that two patients still had severe BAM and one had borderline BAM contributes to the finding that BAM is not secondary to SIBO in right-sided hemicolectomy patients.

The main strength of the present study is that all participants underwent standard evaluation for chronic loose stools to rule out more common causes of bowel dysfunction. Hereafter, all participants underwent systematic investigation with SeHCAT scan, breath test and measurement of GITT. The small number of study participants is, however, a limitation. Cholecystectomy is a well-known cause of BAM though the exact causative mechanism remains obscure [7]. In

the present study, patients having post-cholecystectomy symptoms before undergoing right-sided hemicolectomy were excluded. Thus, the two cases and one control patient, who had cholecystectomy performed before the right-sided hemicolectomy, had no symptoms after the first operation. Unfortunately, we had no information on dietary habits of the controls diagnosed with BAM. If they ate a fat-reduced diet, it might explain their normal bowel function despite low SeHCAT retention levels. As measurement of FGF19 was an add-on investigation, a fasting blood sample for analysis of FGF19 was available for only half of the participants. Larger data sets are needed to firmly conclude if an impaired production of FGF19 plays a role in BAM following right-sided hemicolectomy in cancer patients.

We have previously shown that adjuvant chemotherapy has no impact on the risk of bowel dysfunction following right-sided hemicolectomy [2]. This is supported by the present study where an equal proportion of cases and controls had undergone adjuvant chemotherapy.

Our results suggest that even small resections of the terminal ileum may lead to BAM. Unfortunately, we had no information regarding the exact length of resected ileum, however, it was estimated to 5–10 cm. Future studies may investigate the association between length of the ileal resection and BAM/chronic loose stools.



**FIGURE 2** The association between fibroblast growth factor 19 (FGF19) and selenium-75 homocholeic acid taurine (SeHCAT) retention in 21 cases and nine controls

In conclusion, we have found that BAM is extremely common in patients treated with right-sided hemicolectomy for cancer. Furthermore, BAM is most likely the cause of chronic loose stools seen in survivors after right-sided colon cancer, while SIBO seems of lesser clinical importance.

#### AUTHOR CONTRIBUTIONS

**H M Larsen:** Conceptualization; Writing - original draft; Formal analysis; Project administration; Methodology; Funding acquisition; Investigation; Visualization; Data curation; Writing - review and editing. **K Krogh:** Conceptualization; Methodology; Visualization; Supervision; Investigation; Funding acquisition; Writing - review and editing. **M Borre:** Investigation; Data curation; Writing - review and editing. **T Gregersen:** Investigation; Data curation; Writing - review and editing. **M Mejlby Hansen:** Investigation; Data curation; Writing - review and editing. **A K Arveschoug:** Investigation; Methodology; Writing - review and editing. **P Christensen:** Funding acquisition; Writing - review and editing. **A M Drewes:** Supervision; Visualization; Writing - review and editing. **K J Emmertsen:** Data curation; Writing - review and editing. **S Laurberg:** Supervision; Conceptualization; Visualization; Investigation; Methodology; Funding acquisition; Writing - review and editing. **J L Fassov:** Conceptualization; Investigation; Methodology; Visualization; Supervision; Data curation; Writing - review and editing.

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#### CONFLICT OF INTEREST

The authors declare no conflicts of interest.

#### DATA AVAILABILITY STATEMENT

Research data are not shared.

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