Hernia at the stoma site after loop ileostomy reversal

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Abstract

Purpose To estimate the incidence of and risk factors for stoma site hernia after closure of a temporary diverting ileostomy.

Method In a non-comparative cohort study, charts ($n = 216$) and CT-scans ($n = 169$) from patients who had undergone loop ileostomy closure following low anterior resection for rectal cancer 2010–2015 (mainly open surgery) at three hospitals were evaluated retrospectively. Patients without hernia diagnosis were evaluated cross-sectionally through a questionnaire ($n = 158$), and patients with symptoms of bulging or pain were contacted and offered a clinical examination or a CT scan including Valsalva maneuver.

Results In the chart review, five (2.3%) patients had a diagnosis of incisional hernia at the previous stoma site after 8 months (median). In 12 patients, the CT scan showed a hernia, of which 8 had not been detected previously. The questionnaire was returned by 130 (82%) patients, of which 31% had symptoms of bulging or pain. Less than one in five of patients who reported bulging were diagnosed with hernia, but the absolute majority of the radiologically diagnosed hernias reported symptoms. By combining clinical and radiological diagnosis, the cumulative incidence of hernia was 7.4% during a median follow up time of 30 months. Risk factors for stoma site hernia were male sex and higher BMI.

Conclusion Hernia at the previous stoma site was underdiagnosed. Less than a third of symptomatic patients had a hernia diagnosis in routine follow up. Randomized studies are needed to evaluate if prophylactic mesh can be used to prevent hernias, especially in patients with risk factors.

Keywords Loop ileostomy · Hernia · Rectal cancer · Colorectal surgery

Abbreviations

ASA	American society of anesthesiologists-classification
MRI	Magnetic resonance imaging
BMI	Body mass index
N	number
IQR	Interquartile range

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Introduction

In low anterior resection, a temporary diverting ileostomy is often placed [1–3] to reduce the risk and consequences of a possible leakage [1]. Complications from ostomies include excessive fluid loss, leakage, prolapse, and hernia, why reversal is prioritized [1, 4–8]. Stoma reversal is, however, associated with risk of ileus, infections, and hernia at the former stoma site [9, 10]. A hernia may cause discomfort and pain, and more severe conditions such as bowel obstruction or strangulation.

The incidence of stoma site hernia has been reported between 9.6% and 34.6% [11–19] (Appendix Table 5). Differences may be explained by mixed populations with both colostomies and ileostomies [11, 12, 15–17], and different methods for diagnosis, either computer tomography (CT) scan alone [13, 19] or combined with patient evaluation [17, 20]. Some previous studies have few patients [11, 14] or use old surgical techniques [14]. In a review of 15 studies, the hernia rate was in median 8.3% but 30% in studies with low risk of bias [16].

The primary aim of this study was to investigate the cumulative incidence of hernia in patients undergoing loop ileostomy reversal after low anterior resection for rectal cancer

and the correlation between CT scan and patient-reported symptoms. Secondly, we wanted to evaluate risk factors for developing stoma site hernia.

Ethics

The study was approved by the Regional Ethics Committee in Stockholm (Dnr 2017/1693–31/2).

Method

This non-comparative retrospective cohort study estimated the cumulative incidence of incisional hernia at the site of previous temporary diverting loop ileostomy, through investigation of patients' medical records and re-evaluation of CT and magnetic resonance imaging (MRI) scans. Patient symptoms were evaluated cross-sectionally through questionnaires. The data are reported using a STROBE checklist [21].

We used the definition of hernia proposed by Korenkov et al. in 2001: "Any abdominal wall gap with or without a bulge in the area of a post-operative scar perceptible or palpable by clinical examination or imaging" [22]. Because of the retrospective design, no measure of the abdominal wall gap was possible [23].

Data on patient characteristics, short-term complications, and hernia diagnosis during follow-up were extracted from patient charts by a single examiner (FZV) in 2018, and the radiological re-evaluation was performed by a radiologist (EF) in the first part of 2018. The patient questionnaires were sent out during 2018, and follow-up contact and clinical evaluation was performed during the following month by three surgeons (KE, ÅHE, and JN). The clinical evaluation and diagnosis were based on a distinct reducible bulge in the area of the scar. Unclear cases were offered CT with Valsalva maneuver.

Study population

The study population consisted of all patients who had undergone low anterior resection for rectal cancer with a temporary diverting loop ileostomy and who had undergone stoma reversal within the time period of 2010–2015 at three Stockholm hospitals (Södertälje Hospital, Ersta Hospital, and Stockholm South General Hospital). The patients were identified from the surgery planning and scheduling system (Orbit, Evry Healthcare Systems AB, Kristianstad, Sweden) and selected using surgery codes JFG23 (closure of enterostomy with anastomosis of the small intestine), JFG00 (closure of loop enterostomy without intestinal resection), or JFG20 (closure of enterostomy with intestinal resection). All patients were also required to have the diagnosis code C209 (rectal cancer). There were no exclusion criteria.

Sample size was 216 medical records, and 169 patients had an available CT or MRI scan. In order to detect unrecorded cases of hernia, we sent a letter to living patients who had not already been diagnosed with stoma site hernia. Patients with cancer recurrence were excluded from this part of the study, mainly because we would likely not be able to offer them treatment (operation) if they were diagnosed with hernia. Also, their symptoms would be more difficult to evaluate. The questionnaire was sent out to 158 patients.

Outcome

The records were evaluated for hernia diagnosis, (K43, K45, and K46) or hernia operation (JAD). CT and MRI scans were submitted to a radiologist for re-evaluation of radiological signs of incisional hernias. Cancer follow-up in Sweden is performed 1 and 3 years after surgical treatment by radiological and clinical investigation. For some patient's, radiological follow-up was performed by ultrasonography of the abdomen and plain chest x-ray, which is why in these patients there were no CT scans to evaluate. In some patients, due to local practices, MRI was used instead of CT.

The study-specific questionnaire had the following questions:

Have you undergone surgery for abdominal wall hernia after your last follow-up?

Do you have a protrusion at the site of, or in the proximity of, your previous stoma?

Do you have pain or discomfort at the site of, or in the proximity of, your previous stoma?

Patients who replied yes to any question were contacted by phone, where we further evaluated the symptoms and whether the patients were bothered by them. These patients were offered a clinical examination, and in unclear cases, a CT scan with Valsalva maneuver.

Covariates

Baseline characteristics included: age at the time of primary cancer surgery, sex, smoking, BMI, American Society of Anesthesiologists (ASA) classification [24], type of access at primary surgery, time from ileostomy construction to reversal, and anastomosis method during ileostomy reversal.

Statistical analyses

Continuous variables are presented as mean and median with interquartile range (IQR). Categorical variables are presented as number (*n*) and percent (%). The total number of hernias

Table 1 Baseline characteristics for patients having a temporary loop ileostomy reversed 2010–2015

<i>Number of patients</i>	216
<i>Age (years)</i>	
Mean, median (IQR) in years	62; 63 (55–70)
<i>Sex, n (%)</i>	
Women	86 (40)
Men	130 (60)
<i>Smoking, n (%)</i>	
Smokers	11 (5.1)
Non-smokers	178 (82)
Unknown	27 (12)
<i>Body mass index (BMI)</i>	
Mean; median (IQR)	26; 25 (23–28)
<i>American society of Anesthesiologists (ASA) Classification, n (%)</i>	
I	59 (27)
II	121 (56)
III	35 (16)
IV	1 (0.5)
<i>Type of surgical access at primary surgery, n (%)</i>	
Laparotomy	203 (94)
Laparoscopy	10 (4.6)
Conversion from laparoscopy to laparotomy	3 (1.4)
<i>Cancer stage at primary surgery</i>	
<i>T stage</i>	
T0	14 (6.5)
T1	22 (10)
T2	61 (28)
T3	113 (52)
T4	6 (2.3)
<i>N stage</i>	
N0	142 (66)
N1	45 (21)
N2	29 (13)
<i>M stage</i>	
M0	212 (98)
M1	4 (1.8)
<i>Neoadjuvant treatment</i>	
Chemotherapy	1 (0.46)
Chemoradiotherapy	38 (18)
Radiotherapy	58 (27)
No neoadjuvant treatment	119 (55)
<i>Adjuvant therapy</i>	
Chemotherapy	46 (21)
No adjuvant therapy	170 (79)
<i>Time from ileostomy construction to reversal (months)</i>	
Mean; median (IQR)	7.6; 6.0 (4.0–9.0)
<i>Anastomosis method at ileostomy reversal, n (%)</i>	
Sutures	145 (67)
Staples	65 (30)
Staples and sutures	5 (2.3)
Unknown	1 (0.46)
<i>Abdominal wall closure method at ileostomy site, n (%)</i>	
Monofilament thread, one layer	194 (90)
Monofilament, two layers	9 (4.2)
Monofilament and multifilament thread, two layers	8 (3.7)
Monofilament thread, one layer, and simultaneous use of mesh	1 (0.46)
Unknown	4 (1.9)

was estimated by totaling the number of patients with a diagnosis of hernia from either patient charts, CT scans, or follow-up examination, and the proportion was estimated by dividing the total number of hernias by the total number of included patients (including patients lost to follow-up).

We investigated occurrence of stoma site hernia by predefined patient characteristics (sex, age, smoking, surgical approach, BMI, complications, use of antibiotics >1 day, length of stay, time with stoma, abdominal wall closure method, and ASA classification), based on previous knowledge on risk factors for incisional hernia. Complications, according to Clavien-Dindo [25], were divided into two groups for statistical analysis, one consisting of patients with complications categorized as I–V, and the other group containing patients who had no complications. The method of abdominal wall closure was divided into two categories depending on the number of layers of the abdominal wall sutured (either one or two layers closed, the only case with mesh was excluded). Characteristics of patients with and without hernia were compared with Fisher's exact test for categorical variables (sex, smoking, surgical approach, complications according to Clavien–Dindo, use of antibiotics >1 day, abdominal wall closure method, and ASA classification) and with Wilcoxon signed-rank test for continuous variables (age, BMI, days in hospital after ileostomy reversal, and time from ileostomy creation to reversal). Regarding missing data, analyses were conducted with an available case strategy.

Results

The number of patients who had their ileostomy reversed after low anterior resection for rectal cancer from the three centers between 2010 and 2015 was 216, of which 130 (60%) were men and 86 (40%) were women (Table 1). Median age at resectional surgery was 63 (IQR 55–70) years, and median (IQR) BMI was 25 (23–28) kg/m². Of the patients, 59 (27%) were classified as ASA I, 121 (56%) as ASA II, 35 (16%) as ASA III, and 1 (0.5%) as ASA IV. The majority, 178 patients (82%), were non-smokers. The abdominal wall closure at the ileostomy reversal was primarily done by suture in one layer using monofilament in 194 (90%) patients, or two layers in 17 (7.9%) patients, of which 9 (4.2%) with monofilament and 8 (3.7) combining monofilament and multifilament. Only one patient had the abdominal wall closed with a mesh. Four patients had no data available regarding wall closure method. Most of the primary cancer surgeries, 203 (94%), were done with open surgery, 10 (4.6%) were done with laparoscopic surgery, and 3 (1.4%) were converted from laparoscopic to open surgery.

Complications short term

We found that 66 (31%) of the patients had any 30-day complications after stoma reversal, according to the

Table 2 Short-term outcomes in patients having a temporary loop ileostomy reversed 2010–2015 ($n = 216$)

<i>Patients with any type of complication, n (%)</i>	66 (31)
<i>Time in hospital after ileostomy reversal (days)</i>	
Mean; median (IQR)	5.1; 4.0 (3.0–5.0)
<i>Complications after ileostomy reversal (Clavien–Dindo 30), n (%)</i>	
No complication	150 (69)
I	20 (9.3)
II	33 (15)
IIIa	2 (0.93)
IIIb	9 (4.2)
IVa	2 (0.93)
<i>Use of antibiotics > 1 day, n (%)</i>	26 (12)
<i>Category of complications, n (%)</i>	
Surgical	36 (17)
Cardiovascular	5 (2.3)
Non-surgical infections, dehydration neurological complications (other)	25 (12)

Clavien–Dindo classification (Table 2), of which 46 (21%) had more significant complications (Clavien–Dindo II–IV). Antibiotics were used for more than one day in 26 (12%) patients. Reasons for prolonged antibiotic prescription included wound-site infections, urinary tract infections, and other non-surgical infections. We found surgical complications in 36 (17%) of the patients. Median (IQR) stay in hospital was 4.0 (3.0–5.0) days.

Stoma site hernia during follow-up

In the medical records ($n = 216$), we found 5 (2.3%) patients with a clinical diagnosis of stoma site hernia after a median (IQR) follow-up time of 30 (21–33) months. Median time from stoma reversal to hernia diagnosis was 8 (6–20) months.

The total number of patients who had radiological follow-up with CT scan or MRI scan was 179, i.e., 33 patients had no available CT or MRI scan. Five CT scans and five MRI scans did not possess the qualities needed for the radiologists to be able to diagnose hernias, leaving 169 patients who had useful radiological imaging (Fig. 1).

When re-evaluating the CT and MRI scans, 12 stoma site hernias were found, of which 4 correlated with clinical hernias found in the charts and 8 were not previously known. These 8 hernias had not been detected during the previous radiological evaluation. The cumulative incidence of stoma site hernia was thus 7.1% (12/169) among patients with available radiological follow-up.

At the time point of the evaluation, 158 patients were alive, not already diagnosed with stoma site hernia, and

did not have cancer recurrence. The questionnaire was sent out to all these patients and was answered by 130 (82%). More than a fourth, 37 (28%) of the patients had symptoms of bulging, 19 (15%) had pain at the stoma reversal site and 13 (10%) had both bulging and pain (Table 3). However, only 22% reported inconvenience.

Of the 37 patients with bulging, 7 were diagnosed clinically with hernia of which 4 were also verified by the previous CT. In one patient, the CT scan could not confirm the hernia diagnosis, and 2 patients did not have useful imaging.

Of the new hernias found by re-evaluating CT and MRI ($n = 8$), 7 patients answered the questionnaire and all but one patient reported symptoms (86%). In few patients with symptoms of hernia, the diagnosis could not be confirmed clinically ($n = 8$), and they were referred for CT with Valsalva maneuver. Six of them already had a normal CT, and the results were congruent. No new hernias were found with this method.

There was thus a significant overlap of clinical diagnosis, radiological diagnosis, and patient-reported symptoms. In the entire group of 216 patients, 16 hernias were found, giving a total cumulative incidence of stoma site hernia of 7.4%.

Risk factors

Median BMI in patients with stoma site hernia was 28 (IQR: 25–29) kg/m^2 versus 25 (22–28) in patients without hernia ($p = 0.026$) (Table 4). Of the 16 patients with hernia, 14 (88%) were men and 2 (12%) were women, versus 116 (58%) men and 84 (42%) women in patients without hernia

Fig. 1 Flow-chart of evaluation of outcome

($p = 0.031$). Patient's age, smoking, surgical approach, complications, type of abdominal wall closure, ASA classification, time from ileostomy construction to reversal, and use of antibiotics at more than one day did not differ between patients with and without stoma site hernia.

Discussion and conclusion

The present study shows a cumulative incidence of stoma site hernia of 7.4% after loop ileostomy reversal. Hernia was in many cases unrecorded in the patient charts and re-evaluation of CT scans, and a simple questionnaire provided valuable information. Bulging and pain in the former stoma site were common symptoms, and 22% of the patients reported inconvenience. Among the radiologically diagnosed hernia patients that received the questionnaire, 86% of the patients reported symptoms.

Previous studies have shown an incidence of hernia of up to 34.6% [16, 17] (Appendix Table 5). The reasons for the large variations may be multifactorial. Many of the studies include both small and large bowel ostomies [11, 12, 15–17]. Hernias may be more common after reversal of large bowel ostomies principally because of the larger size of the abdominal wall defect. But even in studies including only loop ileostomy reversals, the incidences have been reported higher than in our study: 11.1% [19], 14.9% [13], and 23.9% [20], respectively. All of them primarily used CT scans for evaluation.

The surgical technique is a factor that can potentially influence the hernia rate. In this study, one suture layer was predominantly used, and still a low hernia rate was found. One study investigated the correlation between the competence of the surgeon and the hernia rate and found no difference in

outcome [18]. They did also not find any significant difference in hernia rate depending on whether fascia closure was performed with absorbable or non-absorbable sutures. The most effective closure of stoma wounds remains unclear, but the use of mesh could potentially lower the incidence of hernia. For example, two retrospective studies comparing patients operated with and without use of mesh showed large differences between groups 1% versus 17% [15] and 6.4% versus 36.1% [26].

High BMI and male sex were significant risk factors in this study. BMI has been shown to be a risk factor in many other studies [12, 13, 17, 18] and is a factor to consider when choosing a technique for the reversal of the ostomy. Other studies have found female sex to be a risk factor for recurrence after incisional hernia repair [27]. Stoma-related problems such as prolapse and parastomal hernia have been shown to be associated with an increased risk of developing stoma site hernia [17]. Colostomies had a higher risk than ileostomies in Sharp et al. [12], but in other studies a colostomy was a risk factor only in patients with malignant disease [17]. Other risk factors for developing hernia after stoma reversal that have been reported are surgical site infection [11, 18], diabetes [12], age [12], urgent operation [12], longer time between primary surgery and reversal [13], and hypertension [17, 20]. One study did not find any significant risk factors at all [19].

An aspect that has not been well studied is if the hernia rate is affected by type of primary surgery (open or laparoscopic). A study where the primary operation was done with open surgery in the majority of cases found a hernia incidence of 11.1% compared with 14.9% [13] where most surgeries were done laparoscopically. In the English study, open technique during the primary operation was a risk factor for hernias, but in contrast, in the study from Belgium more stoma site hernias were found in the laparoscopic group [19]. According to Li W

Table 3 Correlation between patient reported symptoms and clinical/radiological hernia diagnosis ($n = 130$)

Questionnaire	Radiological or clinical hernia diagnosis <i>n</i>	No radiological or clinical hernia diagnosis <i>n</i>	PPV
<i>Bulging</i> $n = 37$ (28%)	7	30	19%
<i>Pain</i> $n = 19$ (15%)	2	17	11%
<i>Bulging and pain</i> $n = 13$ (10%)	2	11	15%
<i>No bulging or pain</i> $n = 87$ (67%)	1	86	1%

PPV positive predictive value

et al., 2017, more complications with parastomal hernias were seen if the specimen was extracted at the stoma site in laparoscopic surgery, but no increase in stoma site hernia after stoma

reversal [28]. In the present study, the hernia incidence was low, even though the majority of primary surgeries were performed by open surgery. The results regarding hernia at the

Table 4 Characteristics of patients with and without stoma site hernia ($n = 216$)

Variables	With stoma site hernia ($n = 16$)	Without stoma site hernia ($n = 200$)	<i>p</i> value
Sex, <i>n</i> (%)			0.031^a
Male	14 (88)	116 (58)	
Female	2 (12)	84 (42)	
Median (IQR) age at surgery	63 (52–66)	63 (55–70)	0.29 ^b
Smoking¹, <i>n</i> (%)¹			1.0 ^a
Yes	0	11 (6.2)	
No	13 (100)	165 (94)	
Surgical approach²			1.0 ^a
Laparoscopic	0	10 (5.0)	
Laparotomy	16 (100)	190 (95)	
BMI, median (IQR)	28 (25–29)	25 (22–28)	0.026^b
Complications			1.0 ^b
No complication	11 (69)	139 (70)	
Clavien-Dindo I-IV	5 (31)	61 (30)	
Use of antibiotics > 1 day <i>n</i> (%)	5 (31)	15 (9.9)	0.119 ^b
Days in hospital, median (IQR)	3 (2.0–5.3)	3 (3.0–5.0)	0.496 ^a
Time from ileostomy construction to reversal in months, Median (IQR)	6.0 (4.8–9.5)	7.0 (4.0–9.0)	0.578 ^a
Abdominal wall closure method, layers, <i>n</i> (%)³			0.745 ^b
1	14 (88)	135 (91)	
2	2 (12)	13 (8.8)	
ASA-classification, <i>n</i> (%)			0.547 ^b
I-II	12 (75)	126 (83)	
III-IV	4 (25)	25 (17)	

Statistically significant values in bold

BMI, Body mass index; ASA, American Society of Anesthesiologists

^a *p* values were calculated using Fisher's exact test^b *p* values were calculated using Wilcoxon signed rank test¹ Patients with missing data were excluded ($n = 27$)² Patients who had a laparoscopy converted to laparotomy were included in the laparotomy group³ Patients with use of mesh or missing data were excluded ($n = 3$)

stoma-site after different surgical approaches are thus mixed and not obviously worse after open primary surgery, as when it comes to the midline incision hernias.

One third of the patients in our study reported symptoms, and most of the patients with stoma site hernia had symptoms of bulging, pain, or both. Nevertheless, in most of the patients with bulging and/or pain (33% of the patients), we found no hernia, i.e., the positive predictive value of bulging, pain, or both was low. However, the negative predictive value was very high; in patients without symptoms, 99% did not have a hernia.

Strengths and limitations

The strength of this study is its very homogenous patient group with only loop ileostomies, and its comprehensive evaluation of patient chart diagnosis, use of imaging, and questionnaires, making it possible to correlate patient symptoms with the hernia diagnosis. We included all patients undergoing loop ileostomy reversal after rectal cancer surgery, and there was therefore no selection bias. As in all chart-based reviews, there may be randomly distributed errors, but such misclassification should not influence our results. The questionnaire was simple and not validated but was only used as a tool to identify patients in need of further clinical evaluation. The hernia diagnosis was determined by experienced surgeons, according to regular clinical praxis.

A limitation of this study is its retrospective design where some of the patients were lost to follow-up and could not be evaluated by questionnaire. Another limitation is that not all patients in the study had CT or MRI scans that could be evaluated. This could have led to an underestimation of the true hernia rate and be one possible explanation for the low incidence of hernia in this study. We also had few events, which limits the possibility to evaluate risk factors for hernia, as well as statistical precision.

The sensitivity of hernia diagnosis increases, according to some studies, with the use of the Valsalva maneuver during CT [29]. In a study from 2005, patients were investigated with both regular CT and CT with Valsalva maneuver, and 10% more hernias were detected with CT with Valsalva maneuver compared with regular CT with intravenous contrast. If a CT with Valsalva maneuver had been performed on all patients in our study, it is possible that more hernias could have been found, including subclinical hernias that could lead to symptoms later in life [30, 31].

Surgical technique during primary surgery has changed since 2010 in our setting, which may influence the generalizability of our results. The change to laparoscopic colorectal

surgery came relatively late in Sweden compared with the rest of Europe. Nowadays, more than 50% of rectal cancer surgery is performed using laparoscopic technique compared with 5% in the beginning of the study period. The impact of the primary surgery on the hernia incidence at the stoma site is not clear, as described above, but may have an impact. It would be interesting to compare our results with a cohort of more recent date.

Clinical implications

We found most of the hernias through re-evaluation of the CT scans in patients that did not have a clinical diagnosis. This indicates that hernia diagnosis was underdiagnosed in a population where repeated postoperative clinical examinations and radiology had been performed. One possible explanation is that both the radiologists and the surgeons had been focused on the primary reason for the investigation (looking for cancer recurrence) and thereby missed a detectable hernia. More hernias could be diagnosed during follow-up if clinicians routinely asked for evaluation of the abdominal wall during CT scans.

We also identify the need for more studies investigating complications after reversal of colostomies, since most previous studies have either mixed populations or only ileostomies [32]. Further research is also needed on the prevention of hernias by use of mesh [33], especially in high-risk groups for hernia, such as obese men.

Conclusion

The cumulative incidence of stoma site hernia after loop ileostomy reversal in this study was 7.4%, but only 2.3% had a diagnosis in the patient chart. Men and patients with higher BMI were at an increased risk of developing stoma site hernia. Randomized studies are needed to evaluate if prophylactic mesh can be used to prevent hernias, especially in patients with risk factors.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest

Appendix

Table 5 Previous studies investigating hernia at the site of stoma closure

Author	Study type	Main results	Comments
Sharp SP 2015, Am Surg USA	Retrospective <i>n</i> = 365	Hernia rate 19% Risk factors age, diabetes, Colostomies, BMI, urgent op	– mixed colostomies and ileostomies
De Keersmaecker G, 2016, Hernia, Belgium	Retrospective, <i>n</i> = 153	Hernia rate 11.1% No significant risk factors	+ only TDI after rectal cancer + after laparotomy 65.4% + CT scans evaluated by two radiologists – no information about symptoms
Fazekas B, 2017, Ann R Coll Surg, England	Retrospective <i>n</i> = 121	Hernia rate 14.9% Risk factors BMI, lower age, open surgery, longer reversal time, and a history of previous hernias	+ only TDI after rectal cancer – after laparoscopy 88.5% – only CT scans + 2.8 CT/pt
Amelung FJ, 2018 BJS Open, The Neatherlands	Retrospective <i>n</i> = 318	Hernia rate 34.6% Risk factors BMI, stoma prolapse, parastomal hernia, and hypertension. Colostomies only if malignant disease	+ chart review, CT, and patient contact – both colostomies and ileostomies 77.3% symptomatic
Brook AJ, 2018, The Surgeon, Ireland	Retrospective <i>n</i> = 139	Hernia rate 13.5% Risk factor SSI (surgical site infection) BMI Suture technique did not matter	+ only loop ileostomy reversal but mixed indications
Brad S Oriel, 2017, Am J of Surgery, USA	Retrospective <i>n</i> = 114	Hernia rate 9.6% Risk factor SSI	– both colostomies and ileostomies + longer follow up, > 5 y
Warren JA, 2018, USA	Retrospective review with and without mesh at stoma reversal	Hernia rate 17.2% without mesh 1% with mesh	– less infections with mesh – both colostomies and ileostomies
Guzman, 2008, Hernia, Mexico	Retrospective <i>n</i> = 70	Hernia rate 31.4%	– fascia closure with absorbable multifilament
Nguyen MT, 2014, J Surg Res USA	Review 15 studies 1650 pt	Hernia rate median 8.3% (range 0–33.9%) Around 30% in the studies with low risk for bias	– both ileo- and colostomies, more ileostomies
Lambrichts, DPW, 2018, Colorect Dis, England	Systematic review 30 studies	Hernia rate 6.5% (range 0–38.5%) Hernia rate in studies with hernia as primary outcome 17.7% 36.1% without mesh 6.4% with mesh	
Kaneko T, 2018, Hernia, Japan	Retrospective <i>n</i> = 134	Hernia rate 23.9% Risk factor hypertension Midline incisional hernia	+ only loop ileostomy reversal + CT scans

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