

Urinary dysfunction in patients with rectal cancer: a prospective cohort study

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Received 8 February 2019; accepted 27 May 2019; Accepted Article online 23 July 2019

Abstract

Aim Urinary dysfunction is one of many complications after treatment for rectal cancer. The aim of this study was to evaluate the prevalence of patient-reported urinary dysfunction at the time of diagnosis and at 1-year follow-up and to assess the risk factors linked to urinary incontinence.

Method Patients with newly diagnosed rectal cancer were included in the QoLiRECT study between 2012 and 2015. Questionnaires from the time of diagnosis and 1-year follow-up were analysed, with 1085 and 916 patients, respectively, eligible for analysis. Regression analyses were made to investigate possible risk factors for incontinence. The patient cohort was also compared with a cohort from the Swedish general population.

Results At baseline, the prevalence of urinary dysfunction (14% of women, 8% of men) was similar to that in the general population. At 1-year follow-up, 20% of patients experienced urinary incontinence (29% of women, 14% of men). Emptying difficulties were experienced by 46% (41% of women, 49% of men) and urgency by 58% across both sexes. Abdominoperineal

excision and urinary dysfunction at baseline were found to be independent risk factors for incontinence at 1-year follow-up. Among patients who were continent at baseline, risk factors were female sex, physical inactivity at baseline, comorbidity and abdominoperineal excision.

Conclusion Urinary dysfunction is frequent among patients with rectal cancer, with up to a two-fold increase in symptoms 1 year after diagnosis. Unfortunately, few factors are modifiable and these results stress the importance of informing patients of possible outcomes related to urinary dysfunction after treatment for rectal cancer.

Keywords Urinary dysfunction, rectal cancer, PROM

What does this paper add to the literature?

It is important to improve our knowledge about possible side effects affecting patients after treatment for rectal cancer. This article shows that urinary dysfunction is common in a large unselected population of patients with rectal cancer, with risk factors for incontinence related to both the patient and the cancer treatment.

Introduction


Rectal cancer is one of the most common cancers in the world. Survival has improved over the last decades [1], mostly due to improved treatment [2]. However, treatments may cause morbidity and various forms of functional impairment [3]. With improved survival, functional impairment as reported by the patient has

received increasing attention. One such impairment is urinary dysfunction.

Previous studies have shown a prevalence of urinary dysfunction of between 6% and 77% after rectal cancer surgery [4,5]. Different definitions, along with different time frames, may explain this variation in the reported prevalence of urinary dysfunction. There is no general consensus in the literature about how to define urinary dysfunction after rectal cancer surgery. Many different scores and descriptions have previously been used, such as the International Prostate Symptom Score (IPSS) [6–9], long-term catheterization [10], voiding problems [11,12] or urinary incontinence [13]. The

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studied time frame varies from 7 days [14] up to 5 years [13] after surgery.

The underlying mechanism in the development of urinary dysfunction in patients treated for rectal cancer is not completely clear. There are conflicting views on, for example, the impact of preoperative radiotherapy [5,13,15], age [15,16], sex [13,17] and type of surgery [5,7,15,18] on urinary dysfunction. Most studies recognize that nerve damage during surgery and preoperative urinary dysfunction are important risk factors [10,13,19].

The aim of this study was to investigate the prevalence of urinary dysfunction in patients with rectal cancer prior to treatment and at 1-year follow-up. A secondary objective was to identify possible preoperative risk factors for the development of urinary incontinence at 1-year follow-up.

Method

The QoLiRECT study

Quality of Life in Rectal Cancer (QoLiRECT) is a prospective, observational multicentre study of patients with rectal cancer. The study included patients from 16 Swedish and Danish hospitals. All patients above the age of 18 years with a confirmed adenocarcinoma of the rectum, i.e. up to 15 cm from the anal verge, who understood either Swedish or Danish were eligible for inclusion. Patients were asked to participate in the study at the time of diagnosis but before initiation of treatment. Those who gave informed consent were asked to complete a detailed questionnaire. Between February 2012 and September 2015, 1248 patients were included in the study. A total of 1085 patients returned the questionnaire at baseline. Patients were subsequently contacted by the study secretariat and asked to fill out similar questionnaires at 1, 2 and 5 years after the diagnosis. All patients included in the study were contacted at all follow-up points, regardless of whether they had filled out the baseline questionnaire or not. A total of 920 patients answered the 1-year questionnaire, including 33 patients who had not answered the baseline questionnaire. This analysis is based on data from the questionnaire at baseline and at 1-year follow-up. Cystectomy at index rectal cancer surgery was an exclusion criterion for 1-year follow-up analyses, rendering 916 patients eligible for analysis.

Questionnaire data

The questionnaires included items covering socioeconomic background, lifestyle factors, overall quality of

life as well as urinary, bowel, sexual and stoma function. The questionnaires were developed using validated and previously described methods [20,21]. In-depth qualitative interviews with content analysis to derive new questions were used together with previously validated questions [21,22]. Content validation was performed by an expert panel. The questionnaires were face-to-face validated by patients with rectal cancer [20,21,23]. Patients were asked about the quality, frequency and intensity of symptoms as well as the corresponding distress with a recall period of 1 month [21].

In this article, the questions regarding urinary function were analysed. The baseline and follow-up questionnaires included 12 questions on urinary function [21,24,25].

During analysis, the 12 questions were divided into four categories: incontinence, bladder emptying difficulties, urgency and distress. Incontinence was defined as 'incontinence during daytime and/or night once per week or more'. Both bladder emptying difficulties and urgency were divided into 'never', 'up to 50% of the time' and 'more than 50% of the time'. The symptom-associated distress was derived from the question 'If your urinary function would remain as it is now for the rest of your life, how would you feel about that?' with a cut-off between 'It would not bother me at all' and 'It would somewhat bother me'.

Questions on smoking, alcohol use and physical activity were also analysed. Patients were regarded as smokers if they answered 'Yes, I smoke' regardless of the amount per week. Former and never smokers were merged into one group. Alcohol use was dichotomized between drinking less than or more than 16 standard glasses per week, as has been described in a previous study [26]. Physical activity was measured using the Saltin-Grimby Physical Activity Level Scale [27] with a cut-off between 'Physically inactive' and 'Some light physical activity, at least 4 h per week'. Comorbidity was analysed from a question on the presence of a number of health conditions, including renal disorders, cardiovascular disorders and diabetes, among others. It was defined as the presence of one or more of these conditions.

Swedish reference population

A reference sample of 3000 people born between 1924 and 1983 was derived from the Swedish tax agency. They were contacted between June 2014 and November 2015 and asked to fill out a questionnaire about their health-related quality of life. A total of 1078 people (median age 63 years, range 31–90, 53% women) completed and returned the questionnaire. Eight

questions related to urinary function corresponded to the questions in the QoLiRECT questionnaires. This allowed for comparison between the QoLiRECT population at baseline and 1-year follow-up and the Swedish reference population.

National registries

Data on sex, age, American Society of Anesthesiologists (ASA) classification, tumour stage according to the Union for International Cancer Control (UICC) classification, chemo- and/or radiotherapy, body mass index (BMI), type of surgery (anterior resection or abdominoperineal excision), open or laparoscopic technique and perioperative blood loss were derived from the Swedish ColoRectal Cancer Registry (SCRCR) and from the Danish Colorectal Cancer Group (DCCG) registry. Because of the lack of some of surgical and oncological data in the DCCG registry, a clinical record form was developed at the study secretariat and filled out retrospectively by personnel at the participating Danish hospitals. Data regarding pre- and postoperative chemotherapy, preoperative radiotherapy and type of surgery in the Danish patient population were derived from this clinical record form. Because of frequent missing data in the SCRCR regarding postoperative chemotherapy, this information was retrieved from the 1-year follow-up questionnaire when it was missing in the registry.

Statistical analysis

Prior to analysis, a plan for statistical analysis was developed and finalized. The prevalence of bladder emptying difficulties (more than 50%), day and/or night-time urinary incontinence (at least once every week) and urinary urgency (more than 50%) were compared with the reference population separately for men and women in an age-adjusted analysis using the modified Poisson regression approach of Zou [28].

In the analysis of potential risk factors for urinary incontinence during day and/or night-time at 1 year the following variables were considered: incontinence at baseline, gender, age, smoking status, alcohol consumption, physical activity, comorbidity (baseline variables) and ASA classification, type of surgery (abdominoperineal excision or any other surgery performed such as anterior resection with or without an anastomosis, i.e. Hartmann), technique (laparoscopy versus open), bleeding during surgery, tumour stage (UICC), preoperative chemoradiotherapy, radiation therapy and postoperative chemotherapy (intra-operative and 1-year follow-up variables).

It was hypothesized that preoperative incontinence was a descendant of the baseline variables on causal paths and exploratory analysis confirmed that age, gender, smoking status and comorbidity were associated with preoperative incontinence. This was also confirmed in an analysis of the reference population. It was further found that incontinence at baseline and at 1 year was highly correlated. Consequently, in the analysis of incontinence at 1 year, evaluation was restricted to intra-operative and 1-year follow-up variables, and baseline information was assessed solely through preoperative incontinence. In a subgroup of preoperatively continent patients, both baseline, intra-operative and 1-year follow-up variables were included in the risk factor assessment.

The variables were evaluated using simple and bivariate logistic regression analysis (urinary continence before treatment being included as a fixed effect). A subset of variables was selected using the purposeful selection strategy for logistic regression with the SAS macro [29]. Missing values in the variables selected from the strategy were imputed by multiple imputations by chained equations [30]. The final modelling involved the subsequent estimation and pooling of the multiple regression model across the imputations using *proc mianalyze* in SAS. SPSS version 25 (IBM Corp., Armonk, New York, USA), SAS version 9.4 (SAS Institute, Cary, North Carolina, USA) and R version 3.4.3 (R Foundation for Statistical Computing, Vienna, Austria) were used for calculations and graphics.

Ethics

The QoLiRECT study has obtained ethical approval from the Central Ethical Review Board in Sweden (Dnr 595-11), the Danish Data Protection Agency (HEH.750.89-21, HGH-2016-016) and the Regional Ethical Review Board in Denmark (H-3-2012-FSP26).

Results

Altogether 1085 and 920 patients were available for analysis at baseline and at 1-year follow-up, respectively (Fig. 1). Four patients were excluded at 1 year due to a concomitant cystectomy at their index surgery. One centre was excluded due to a poor inclusion rate in relation to their patient population, giving low external validity. The cohort comprised 64% men. Women had a lower ASA classification and less blood loss than men. Otherwise, there were no clinically relevant differences between men and women regarding comorbidity, lifestyle factors or treatment (Table 1). Patients lost to follow-up between baseline and the 1-year follow-up are

presented in Table 2, indicating no systematic bias in the dropout.

Urinary incontinence was more common among women than men at both baseline (14% *vs* 8%) and 1-year follow-up (29% *vs* 14%) (Table 3). Both men and women had a similar pattern, with almost a two-fold increase in incontinence 1 year after diagnosis.

Bladder emptying difficulties were prevalent to a higher extent in men if all problems were included (43% at baseline and 49% at 1 year) but a more pronounced increase was seen in women at 1 year (28% at baseline and 41% at 1 year) (see Table 3). More men than women used aids for bladder emptying at 1-year follow-up.

The prevalence of urgency was similar in men and women, and increased by approximately 40% at 1 year.

Almost 20% of all patients, both men and women, were distressed about their urinary symptoms at baseline. At 1 year, this figure almost doubled.

Patients reported similar urinary dysfunction to the Swedish reference population at baseline (Fig. 2). At 1 year, patient-reported dysfunction increased in both men and women, as described above.

Risk factors for urinary incontinence are shown in Fig. 3. Preoperative incontinence as well as abdominoperineal excision were independent risk factors for incontinence at 1-year follow-up (Table 4). Comparing abdominoperineal excision and anterior resection, we found that all urinary problems were more common after abdominoperineal excision [urinary incontinence (27% *vs* 17%, $P < 0.05$), urgency (12% *vs* 5%, $P < 0.05$) and evacuation problems (14% *vs* 9%, $P < 0.05$)]. The differences regarding surgical technique were more pronounced in women with regard to urinary incontinence and urgency, but evacuation problems were a little more pronounced in men who underwent abdominoperineal excision. Risk factors for incontinence in the subgroup of preoperatively continent patients at 1-year follow-up are shown in Fig. 4. Identified risk factors were female sex, physical inactivity at baseline, higher ASA classification and abdominoperineal excision.

Discussion and conclusion

The present study showed that urinary dysfunction is a frequent problem from which many patients suffer a

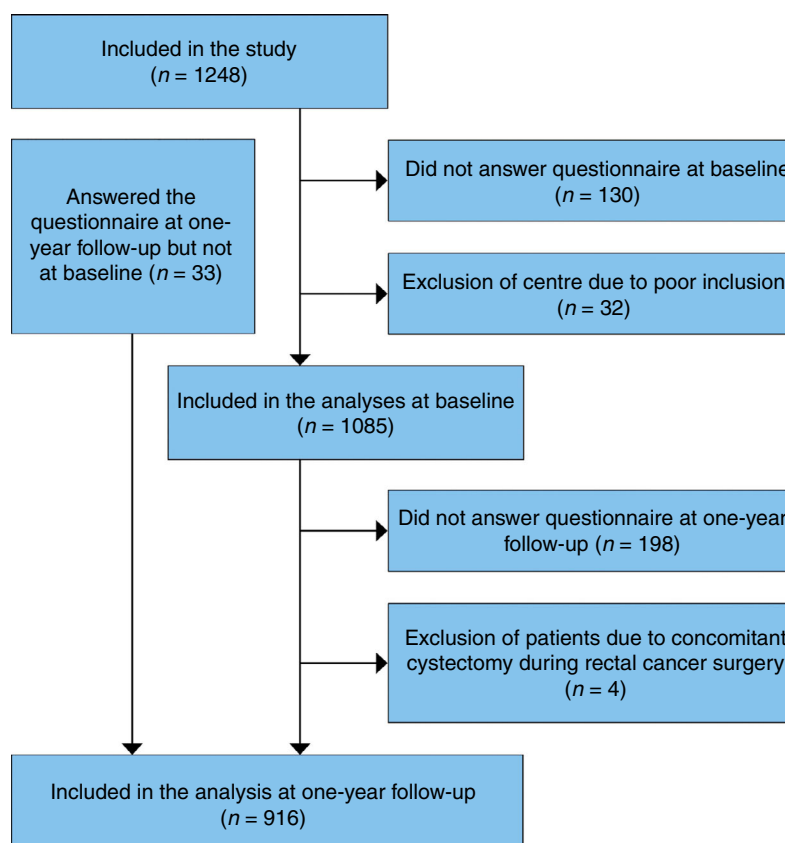


Figure 1 Flow chart.

Table 1 Demography at baseline.

	Women (<i>n</i> = 392), (%)	Men (<i>n</i> = 693), (%)	Total (<i>n</i> = 1085), (%)	Missing data
Curative intended treatment	375 (96)	637 (92)	1012 (93)	0
Palliative intended treatment	17 (4)	56 (8)	73 (7)	0
Age (years), median (range)	68 (25–93)	69 (38–100)	69 (25–100)	0
BMI (kg/m ²), median (range)	25 (22–28)	26 (24–28.5)	25.5 (23–28.5)	162
ASA classification				
I	96 (27)	139 (23)	235 (25)	133
II	213 (61)	351 (58)	564 (59)	
III–IV	42 (12)	111 (18)	153 (16)	
Comorbidity				
Yes	234 (60)	427 (62)	661 (62)	12
No	153 (40)	259 (38)	412 (38)	
Current smoker				
Yes	34 (9)	65 (10)	99 (9)	20
No	353 (91)	613 (90)	966 (91)	
Alcohol intake				
More than 16 glasses per week	4 (1)	34 (5)	38 (4)	46
Less than 16 glasses per week	370 (99)	631 (95)	1001 (96)	
Physical activity				
Physically inactive	54 (14)	102 (15)	156 (15)	48
Some light physical activity or more	324 (86)	557 (85)	881 (85)	
UICC classification*				
0	6 (2)	12 (2)	18 (2)	140
I	114 (33)	164 (27)	278 (29)	
II	80 (23)	144 (24)	224 (24)	
III	110 (32)	186 (31)	296 (31)	
IV	35 (10)	94 (16)	129 (14)	
Preoperative radiation therapy				
Yes	152 (39)	228 (33)	380 (35)	0
No	240 (61)	465 (67)	705 (65)	
Preoperative chemoradiotherapy				
Yes	63 (16)	154 (22)	217 (20)	0
No	329 (84)	539 (78)	868 (80)	
Postoperative chemotherapy				
Yes	145 (39)	246 (38)	391 (38)	64
No	226 (61)	404 (62)	630 (62)	
Operative technique				
Open	162 (46)	299 (50)	461 (48)	133
Laparoscopic	190 (54)	301 (50)	491 (52)	
Type of surgery				
Anterior resection	209 (56)	293 (45)	502 (49)	56
Abdominoperineal excision	108 (29)	223 (34)	331 (32)	
Hartmann's procedure	24 (6)	64 (10)	88 (9)	
No intervention	19 (5)	48 (7)	67 (7)	
Other†	15 (4)	26 (4)	41 (4)	
Perioperative blood loss (ml), (range)	150 (50–300)	250 (100–500)	200 (50–450)	166

*UICC is based on pTNM classification.

†Other includes colectomy, transanal endoscopic microsurgery, local excision, laparotomy without excision and unknown.

long time after they have received their rectal cancer diagnosis and treatment.

Of the various components of urinary dysfunction, urinary incontinence appears to be the most important

problem. The study indicates that incontinence shows a two-fold increase in the patient population following treatment, with approximately one-third of patients experiencing incontinence at least once weekly. As

Table 2 Description of patients who dropped out between baseline and 1-year follow-up.

	Total population at baseline (<i>n</i> = 1085)	Missing information	Drop-out between baseline and 1 year follow-up (<i>n</i> = 198)	Missing information at drop-out
Age (years)	69 (25–100)		71 (35–93)	
Sex				
Female	392 (36)		60 (30)	
Male	693 (64)		138 (70)	
Deceased at 1-year follow-up	0		49	
ASA classification				
I	235 (25)	133	30 (21)	52
II	564 (59)		85 (58)	
III–IV	153 (16)		31 (21)	
Type of surgery				
Anterior resection	502 (49)	56	62 (34)	16
Abdominoperineal resection	331 (32)		49 (27)	
Hartmann's procedure	88 (9)		25 (14)	
No intervention	67 (7)		37 (20)	
Other*	41 (4)		9 (5)	
UICC classification†				
0	18 (2)	140	3 (2)	41
I	278 (29)		33 (21)	
II	224 (24)		37 (24)	
III	296 (31)		50 (32)	
IV	129 (14)		34 (22)	

*Other includes colectomy, transanal endoscopic microsurgery, local excision, laparotomy without excision and unknown.

†UICC is based on pTNM classification.

expected, women had more problems than men (29% compared with 14%), although the increase in incontinence was similar between sexes. There are no data in our study that can explain these differences with regard to tumour stage or surgical technique as this was fairly similar between sexes.

Risk factors for urinary incontinence were incontinence at baseline and abdominoperineal excision. Among patients who were continent at baseline, risk factors were female sex, physical inactivity at baseline, higher ASA classification and abdominoperineal excision. Apart from physical inactivity, these risk factors have been reported previously [5,7,13,15,17,31,32]. In the present study, neither chemotherapy nor radiotherapy was found to be a significant risk factor, which is also consistent with previous findings [13].

We identified the modifiable risk factor of physical inactivity in our study. This warrants further research on how to increase physical activity before treatment in order to improve recovery and possibly urinary function. The question arises as to whether physical therapy before and after treatment could reduce the number of patients with urinary incontinence.

A previous study in 785 patients reported that 38% of patients experienced incontinence and 31% had

bladder emptying difficulties 5 years after surgery [13]. It is probable that the differences in the time frame and the type and interpretation of the questionnaires may explain the different results. However, their 1-year data indicate 30% urinary incontinence and bladder emptying difficulties, which is similar to the present study [13].

In a study on 516 women who underwent abdominoperineal excision or low anterior excision in Denmark between 2001 and 2007, it was reported that 63% and 77% of patients reported incontinence and urgency, respectively [5]. That study used the ICIQ-FLUTS questionnaire to evaluate urinary dysfunction [33]. Although the questions are similar to the present study, the responses were dichotomized into 'occasionally/sometimes/most of the time/all the time' or 'never' and then further dichotomized according to median scores. This dichotomization could be an explanation for the differences between their results and ours. The present study cohort also includes more surgical alternatives, including no surgery at all, and we studied a shorter time frame.

In the AbdominoPerineal Extralevator Resection study (APER), a Swedish cross-sectional study in patients who underwent abdominoperineal excision between 2007 and 2009, 46.5% of patients were

Table 3 Prevalence of urinary dysfunction during the last month.

	Female population at baseline (<i>n</i> = 392), (%)	Female population at 1-year follow-up (<i>n</i> = 347), (%)	Male population at baseline (<i>n</i> = 693), (%)	Male population at 1-year follow-up (<i>n</i> = 569), (%)	Total population at baseline (<i>n</i> = 1085), (%)	Total population at 1-year follow-up (<i>n</i> = 916), (%)
Urinary incontinence during daytime and/or nighttime						
At least once per week	52 (14)	100 (29)	53 (8)	81 (14)	105 (10)	181 (20)
Less than once per week	329 (86)	239 (71)	624 (92)	478 (86)	953 (90)	717 (80)
Urinary incontinence during daytime						
At least once per week	41 (11)	98 (29)	45 (7)	79 (14)	86 (8)	177 (20)
Less than once per week	340 (89)	241 (71)	638 (93)	480 (86)	978 (92)	721 (80)
Urinary incontinence during the night						
At least once per week	26 (7)	33 (10)	20 (3)	26 (5)	46 (4)	59 (7)
Less than once per week	361 (93)	305 (90)	657 (97)	533 (95)	1018 (96)	838 (93)
Urinary incontinence only during physical activity						
Yes	100 (26)	129 (39)	22 (3)	48 (9)	122 (11)	177 (20)
No	65 (17)	85 (25)	106 (16)	137 (25)	171 (16)	222 (25)
Not applicable	216 (57)	120 (36)	554 (81)	372 (67)	770 (72)	492 (55)
Urinary incontinence during sexual activity						
Yes	4 (1)	5 (1)	10 (1)	3 (1)	14 (1)	8 (1)
No	91 (24)	71 (21)	207 (31)	135 (24)	298 (28)	206 (23)
Not applicable	287 (75)	258 (77)	458 (68)	417 (75)	745 (70)	675 (76)
Use of pads or other aids for urinary incontinence						
Yes	79 (20)	132 (39)	35 (5)	62 (11)	114 (11)	194 (22)
No	78 (20)	50 (15)	146 (22)	117 (21)	224 (21)	167 (19)
Not applicable	229 (59)	155 (46)	489 (73)	370 (67)	718 (68)	525 (60)
Bladder emptying difficulties						
More than 50% of the time	23 (6)	37 (11)	46 (7)	61 (11)	69 (6)	98 (11)
Up to 50% of the time	84 (22)	103 (30)	247 (37)	208 (38)	104 (10)	311 (35)
Never or not applicable	274 (72)	199 (59)	383 (57)	280 (51)	884 (83)	479 (54)
Use of aids for bladder emptying (catheter or others)						
Yes	3 (1)	12 (4)	18 (3)	59 (10)	21 (2)	71 (8)
No	383 (99)	325 (96)	664 (97)	504 (90)	1047 (98)	829 (92)
Urgency to urinate						
More than 50% of the time	18 (5)	31 (9)	23 (3)	41 (7)	41 (4)	72 (8)
Up to 50% of the time	137 (36)	166 (49)	254 (38)	280 (51)	391 (37)	446 (50)
Never	196 (51)	129 (38)	326 (49)	192 (35)	522 (50)	321 (36)
Not applicable	33 (9)	14 (4)	67 (10)	41 (7)	100 (9)	55 (6)
Wet themselves because of inability to reach the toilet in time						
More than 50% of the time	5 (1)	3 (1)	3 (0)	4 (1)	8 (1)	7 (1)
Up to 50% of the time	51 (13)	31 (9)	41 (6)	17 (3)	92 (9)	48 (5)
Never or not applicable	329 (85)	307 (90)	624 (93)	531 (96)	953 (91)	838 (94)
If your urinary function would remain as it is now for the rest of your life, how would you feel about that?						
Distressed	75 (20)	125 (37)	112 (17)	174 (32)	187 (18)	299 (34)
Not distressed	35 (9)	40 (12)	51 (8)	50 (9)	86 (8)	90 (10)
Not applicable	270 (71)	174 (51)	510 (76)	328 (59)	780 (74)	502 (56)

regarded as incontinent [32]. However, the definition of incontinence was different from the present study and all patients underwent abdominoperineal excision.

The fact that there is a near two-fold increase in distress in terms of urinary dysfunction over time clearly indicates that such problems are important to patients

and stresses the need to try to prevent and alleviate posttreatment urinary dysfunction. This is of even greater importance when taking into account the fact that one of the risk factors is modifiable.

The main strength of this study is its prospective, unselected, multicentre design and that all treatment

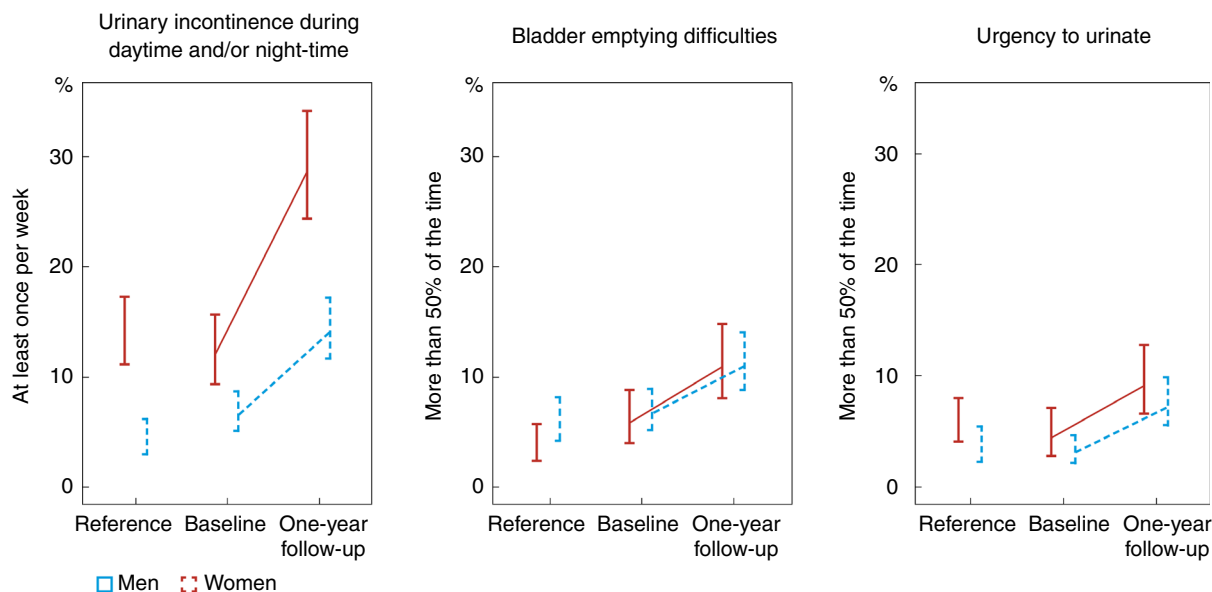


Figure 2 Comparison of study population with Swedish reference population.

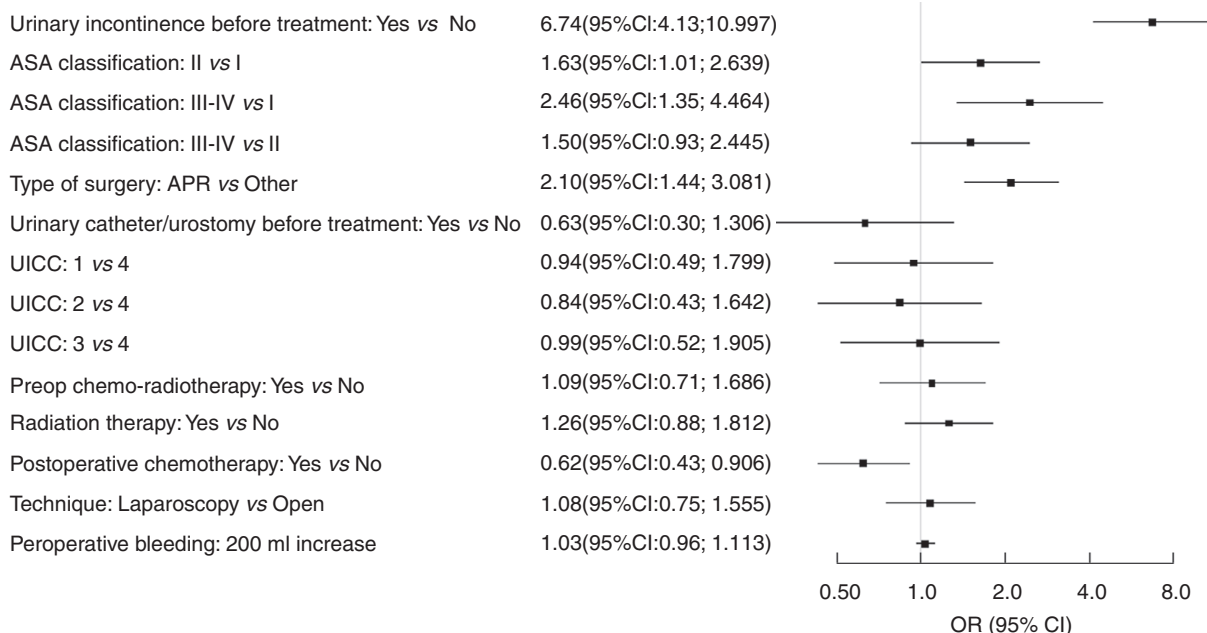


Figure 3 Intra-operative and one-year follow-up risk factors for incontinence (bivariate analysis with urinary continence before treatment included as a fixed effect). Presented as odds ratio and 95% confidence intervals.

possibilities are represented, both palliative and curative. As has been previously reported [34], the patient population is representative of the total Swedish and Danish rectal cancer population. The cohort size is large, with good response rates at baseline and at 1-year follow-up. The questionnaires were developed using previously validated questions. The use of a reference population with

similar results at baseline is also a strength and indicates that patients' problems with urinary dysfunction at 1-year follow-up are largely related to their treatment.

There are some limitations to this study. One is the observational design, which makes it difficult to draw conclusions about causation for the main results. Another limitation is the fact that only patients who

Table 4 Multiple regression with variables chosen from the variable selection strategy.*

Variable	Comparison	OR (95% CI)	P-value
All evaluable patients at 1-year follow-up (<i>n</i> = 916)			
Urinary incontinence before treatment	Yes vs No	6.61 (4.01; 10.87)	< 0.001
Surgical method	APE vs other	2.02 (1.38; 2.94)	< 0.001
Subgroup: preoperatively continent patients (<i>n</i> = 782)			
Sex	Female vs male	2.57 (1.73; 3.84)	< 0.001
Physical activity	Not active vs at least somewhat active	1.88 (1.07; 3.31)	0.0279
ASA classification	II vs I	1.68 (0.98; 2.88)	0.0574
	III–IV vs I	2.66 (1.34; 5.29)	0.005
	III–IV vs II	1.58 (0.90; 2.78)	0.1089
Surgical method	APE vs other	2.15 (1.42; 3.27)	< 0.001
Surgical technique	Laparoscopic vs Open	1.26 (0.84; 1.90)	0.2621

APE, abdominoperineal excision.

*Multiple imputations by chained equations with 50 imputations was used for the selected variables.

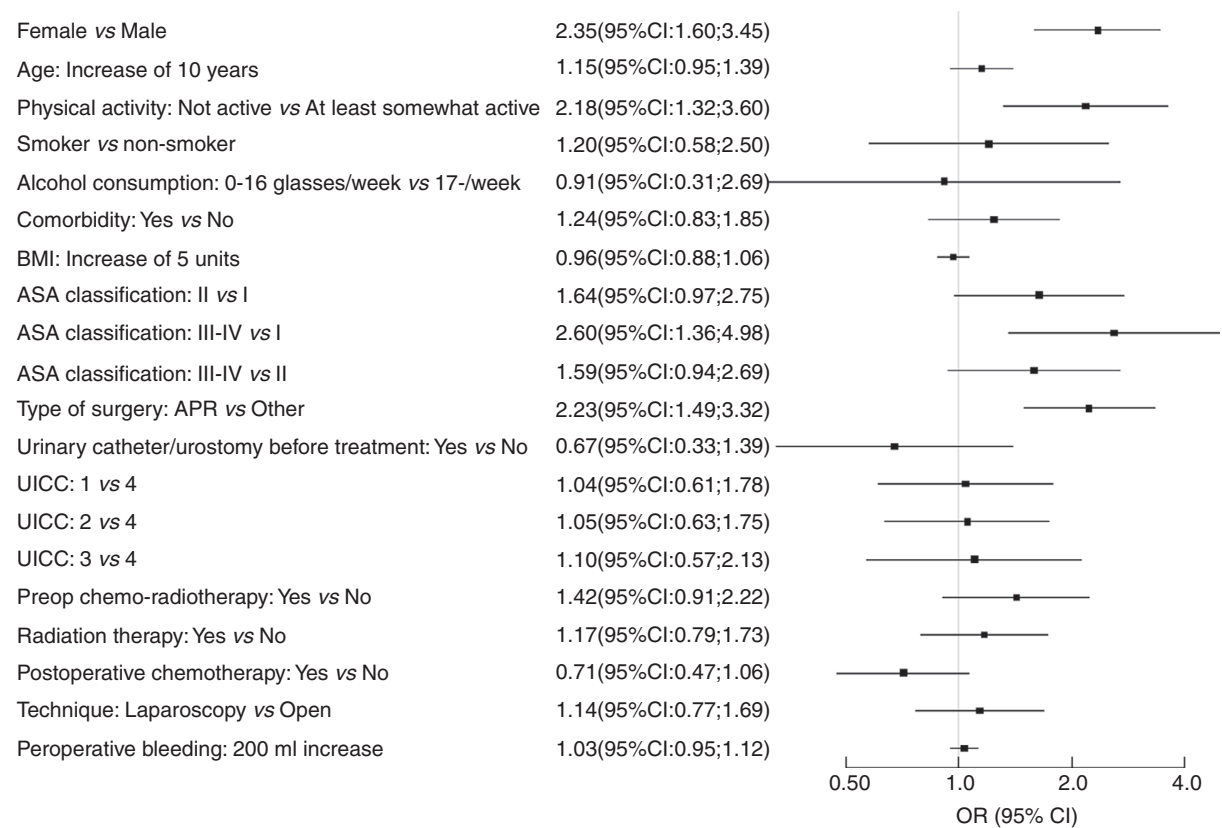


Figure 4 Subgroup of preoperatively continent patients. Baseline, intra-operative and one-year follow-up risk factors for incontinence (univariate analysis). Presented as odds ratio and 95% confidence intervals.

had a good understanding of either Swedish or Danish could participate. However, as previously reported, results have shown the present cohort to be representative, indicating that this is only a minor limitation [34].

As the results indicate that a substantial number of all rectal cancer patients will suffer long-term urinary dysfunction, we stress the importance of informing patients of this prior to treatment. In a previous study in the QoLiRECT population [35], only 32% of

patients reported that they had received information about the possible effects of treatment on urinary function. Since abdominoperineal excision was the only surgical risk factor for incontinence, it is of even greater importance to inform these patients about the possible long-term dysfunctional outcomes.

In conclusion, many patients treated for rectal cancer develop urinary dysfunction, with substantial distress after treatment. Incontinence appears to be the most relevant problem, with a two-fold increase compared with baseline levels. It is important to inform patients of possible treatment-related functional impairments, to identify patients who are at particular risk and to ensure a proper posttreatment follow-up. Further evaluation of modifiable lifestyle factors is warranted to possibly prevent morbidity after treatment for rectal cancer.

Acknowledgements

The authors are grateful for the work performed by the research nurses at the Scandinavian Surgical Outcomes Research Group and by all those involved in the recruitment of patients at participating hospitals: Sahlgrenska University Hospital/Östra; Skaraborg Hospital Skövde; NU Hospital Group, Trollhättan; Central Hospital of Karlstad; Södra Älvsborg Hospital, Borås; Karolinska University Hospital; Örebro University Hospital; Sunderbyn Hospital; Västmanland's Hospital Västerås, Blekinge Hospital, Karlskrona; Mora Hospital; Helsingborg Hospital; Hvidovre Hospital; Slagelse Hospital; Herlev Hospital; and Roskilde Hospital.

Funding: The Swedish Research Council, grant number 2012-1768 and 2017-01103; The Swedish Cancer Society CAN 2013/500 and CAN 2016/509; The Swedish Society of Medicine; The Gothenburg Medical Society; The Healthcare Sub-committee, Region Västra Götaland; ALF grant ALFGBG-526501, ALFGBG-136151, ALFGBG-493341 and ALFGBG-716581 'Agreement concerning research and education of doctors'; Anna-Lisa and Bror Björnsson Foundation; Assar Gabriellsson Foundation; Mary von Sydow Foundation; Ruth and Richard Julin's Foundation, Lion's Cancer Research Foundation of Western Sweden.

Conflicts of interest

None of the authors have any conflicts of interest.

References

1 Kodeda K, Johansson R, Zar N *et al.* Time trends, improvements and national auditing of rectal cancer

management over an 18-year period. *Colorectal Dis* 2015; **17**: O168–79.

- 2 MacFarlane JK, Ryall RD, Heald RJ. Mesorectal excision for rectal cancer. *Lancet* 1993; **341**: 457–60.
- 3 Panjari M, Bell RJ, Burney S, Bell S, McMurrick PJ, Davis SR. Sexual function, incontinence, and wellbeing in women after rectal cancer—a review of the evidence. *J Sex Med* 2012; **9**: 2749–58.
- 4 Jones OM, Stevenson AR, Stitz RW, Lumley JW. Preservation of sexual and bladder function after laparoscopic rectal surgery. *Colorectal Dis* 2009; **11**: 489–95.
- 5 Bregendahl S, Emmertsen KJ, Lindegaard JC, Laurberg S. Urinary and sexual dysfunction in women after resection with and without preoperative radiotherapy for rectal cancer: a population-based cross-sectional study. *Colorectal Dis* 2015; **17**: 26–37.
- 6 Beraldo FB, Yusuf SA, Palma RT, Kharmandayan S, Gonçalves JE, Waisberg J. Urinary dysfunction after surgical treatment for rectal cancer. *Arq Gastroenterol* 2015; **52**: 180–5.
- 7 Duran E, Tanriseven M, Ersoz N *et al.* Urinary and sexual dysfunction rates and risk factors following rectal cancer surgery. *Int J Colorect Dis* 2015; **30**: 1547–55.
- 8 Kneist W, Junginger T. Long-term urinary dysfunction after mesorectal excision: a prospective study with intraoperative electrophysiological confirmation of nerve preservation. *Eur J Surg Oncol* 2007; **33**: 1068–74.
- 9 Asoglu O, Matlim T, Karanlik H *et al.* Impact of laparoscopic surgery on bladder and sexual function after total mesorectal excision for rectal cancer. *Surg Endosc* 2009; **23**: 296–303.
- 10 Kneist W, Heintz A, Junginger T. Major urinary dysfunction after mesorectal excision for rectal carcinoma. *Br J Surg* 2005; **92**: 230–4.
- 11 Nesbakken A, Nygaard K, Bull-Njaa T, Carlsen E, Eri LM. Bladder and sexual dysfunction after mesorectal excision for rectal cancer. *Br J Surg* 2000; **87**: 206–10.
- 12 Kim JH, Noh TI, Oh MM *et al.* Voiding dysfunction after total mesorectal excision in rectal cancer. *Int Neurourol J* 2011; **15**: 166–71.
- 13 Lange MM, Maas CP, Marijnen CA *et al.* Urinary dysfunction after rectal cancer treatment is mainly caused by surgery. *Br J Surg* 2008; **95**: 1020–8.
- 14 Fang JF, Wei B, Zheng ZH *et al.* Effect of intra-operative autonomic nerve stimulation on pelvic nerve preservation during radical laparoscopic proctectomy. *Colorectal Dis* 2015; **17**: O268–76.
- 15 Tekkis PP, Cornish JA, Remzi FH *et al.* Measuring sexual and urinary outcomes in women after rectal cancer excision. *Dis Col Rectum* 2009; **52**: 46–54.
- 16 Ozeki S, Maeda K, Hanai T, Masumori K, Katsuno H, Takahashi H. Effects of robotic rectal surgery on sexual and urinary functions in male patients. *Surg Today* 2016; **46**: 491–500.
- 17 Kim HO, Cho YS, Kim H, Lee SR, Jung KU, Chun HK. Scoring systems used to predict bladder dysfunction after laparoscopic rectal cancer surgery. *World J Surg* 2016; **40**: 3044–51.

- 18 Dulskas A, Samalavicius NE. A prospective study of sexual and urinary function before and after total mesorectal excision. *Int J Colorectal Dis* 2016; **31**: 1125–30.
- 19 Wallner C, Lange MM, Bonsing BA *et al*. Causes of fecal and urinary incontinence after total mesorectal excision for rectal cancer based on cadaveric surgery: a study from the Cooperative Clinical Investigators of the Dutch total mesorectal excision trial. *J Clin Oncol* 2008; **26**: 4466–72.
- 20 Omerov P, Steineck G, Runeson B *et al*. Preparatory studies to a population-based survey of suicide-bereaved parents in Sweden. *Crisis* 2013; **34**: 200–10.
- 21 Steineck G, Bergmark K, Henningsohn L, Al-Abany M, Dickman PW, Helgason A. Symptom documentation in cancer survivors as a basis for therapy modifications. *Acta Oncol* 2002; **41**: 244–52.
- 22 Bergmark K, Avall-Lundqvist E, Dickman PW, Henningsohn L, Steineck G. Vaginal changes and sexuality in women with a history of cervical cancer. *N Engl J Med* 1999; **340**: 1383–9.
- 23 Asplund D, Heath J, Gonzalez E *et al*. Self-reported quality of life and functional outcome in patients with rectal cancer—QoLiRECT. *Dan Med J* 2014; **61**: A4841.
- 24 Haglind E, Carlsson S, Stranne J *et al*. Urinary incontinence and erectile dysfunction after robotic versus open radical prostatectomy: a prospective, controlled, nonrandomised trial. *Eur Urol* 2015; **68**: 216–25.
- 25 Angenete E, Correa-Marinez A, Heath J *et al*. Ostomy function after abdominoperineal resection—a clinical and patient evaluation. *Int J Colorectal Dis* 2012; **27**: 1267–74.
- 26 Angenete E, Angeras U, Borjesson M *et al*. Physical activity before radical prostatectomy reduces sick leave after surgery - results from a prospective, non-randomized controlled clinical trial (LAPPRO). *BMC Urol* 2016; **16**: 50.
- 27 Saltin B, Grimby G. Physiological analysis of middle-aged and old former athletes. Comparison with still active athletes of the same ages. *Circulation* 1968; **38**: 1104–15.
- 28 Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 2004; **159**: 702–6.
- 29 Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. *Source Code Biol Med* 2008; **3**: 17.
- 30 White IT, Roystin P, Wood AM. Multiple imputation using chained equations: issues and guidance for practice. *Stat Med* 2011; **30**: 377–99.
- 31 Dulskas A, Miliauskas P, Tikuisis R, Escalante R, Samalavicius NE. The functional results of radical rectal cancer surgery: review of the literature. *Acta Chir Belg* 2016; **116**: 1–10.
- 32 Ledebø A, Bock D, Prytz M, Haglind E, Angenete E. Urogenital function 3 years after abdominoperineal excision for rectal cancer. *Colorectal Dis* 2018; **20**: O123–34.
- 33 Brookes ST, Donovan JL, Wright M, Jackson S, Abrams P. A scored form of the Bristol Female Lower Urinary Tract Symptoms questionnaire: data from a randomized controlled trial of surgery for women with stress incontinence. *Am J Obstet Gynecol* 2004; **191**: 73–82.
- 34 Asplund D, Bisgaard T, Bock D *et al*. Pretreatment quality of life in patients with rectal cancer is associated with intrusive thoughts and sense of coherence. *Int J Colorectal Dis* 2017; **32**: 1639–47.
- 35 Walming S, Asplund D, Block M *et al*. Patients with rectal cancer are satisfied with in-hospital communication despite insufficient information regarding treatment alternatives and potential side-effects. *Acta Oncol* 2018; **57**: 1311–7.