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ORIGINAL ARTICLE

Long-term Outcomes After Surgery Involving the Pelvic Floor in Rectal Cancer: Physical Activity, Quality of Life, and Health Status

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Abstract

Purpose This study has aimed to evaluate the effects of surgery on physical activity (PA), quality of life (QoL), and disease-specific health status, by analyzing the differences between sphincter-preserving surgery (low anterior resection (LAR)) and abdominoperineal resection (APR) among rectal cancer survivors.

Methods Individuals who were diagnosed with rectal cancer and who underwent an APR or a LAR between 2000 and 2009 were included. The different questionnaires on QoL, disease-specific health status, and physical activity began their surveys in 2010. Differences in QoL, health status, and physical activity were analyzed between the APR group and the LAR group.

Results The study included 905 rectal cancer survivors (LAR, 632; APR, 273). Besides a higher rate of radiotherapy treatment in the APR group (94% vs. 75%, $p < 0.001$), there were no differences in clinical characteristics or in comorbid conditions between the LAR group and APR group. No significant differences were found in PA level between the patients who had undergone an APR vs. a LAR. Regarding QoL, APR patients did report a worse physical ($p = 0.009$) and role functioning ($p = 0.03$), as well as a worse body image ($p = 0.001$), compared to patients who had undergone a LAR. However, they reported fewer constipation ($p = 0.02$) and gastrointestinal problems ($p = 0.009$). Finally, compared to patients who had undergone a LAR with a permanent ostomy, APR patients reported a better body image ($p = 0.048$) and less stoma-related problems ($p = 0.001$).

Conclusions This study showed no differences in PA level among the patients who had undergone an APR versus a LAR. With respect to their QoL, their physical and role functioning seemed to be worse in the APR patients. However, these differences in outcomes resolved when comparing the APR group with patients after a LAR with a permanent ostomy.

Keywords Rectal surgery · Rectal cancer · Functional outcomes · Quality of life · Physical activity

Abbreviations

APR	Abdominoperineal resection
ECR	Eindhoven Cancer Registry
EORTC QLQ-C30	European Organization for Research and Treatment of Cancer Quality of Life Questionnaire
QoL	Quality of life
LAR	Low anterior resection
LARS	Low anterior resection syndrome
LMM	Linear mixed models
PROFILES	Patient Reported Outcomes Following Initial Treatment and Long Term Evaluations of Survivorship
PA	Physical activity

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Introduction

Colorectal cancer is currently the second most common cancer in the Netherlands, with an incidence of approximately 5000 rectal cancer patients per year.[1] For the majority of patients, surgery is still the cornerstone in the curative treatments of rectal cancer. The choice of surgical approach depends upon the tumor's location, together with the possibility of anal sphincter involvement and sphincter function. A low anterior resection (LAR), with preservation of the sphincter function, is generally carried out for middle or high tumors of the rectum. For very low tumors or in the case of sphincter involvement, when sphincter-preserving surgery is not possible, or when it is considered too much of a compromise of the function, an abdominoperineal resection (APR) can be carried out, including the forming of a permanent colostomy.[2]

Surgery in rectal cancer often involves a considerably invasive procedure of pelvic floor repair. Consequently, short- and long-term morbidity after an APR includes pain, a discomfort when sitting, and various complaints relating to the presence of the ostomy are well known.[3] A low anastomosis, as created during a LAR, can cause a variety of symptoms, which are described together as the low anterior resection syndrome (LARS). Symptoms may consist of incontinence, urgency, and frequent bowel movements.[4] These factors can contribute to a worse physical functioning and a poor quality of life (QoL). Besides oncological outcome measures, such as free margins and survival, QoL and sexual (dys)function are important outcome parameters. In the past decade, several studies regarding these matters within rectal cancer have been published.[5–7] In 2013, Konanz et al.[8] described a better physical functioning after sphincter-preserving surgery; however, this was based upon relatively small groups. Large cohort studies comparing QoL between the different surgical procedures for rectal cancer are scarce and the influence of the degree of pelvic floor dissection has not been evaluated before. The importance of QoL in patients after rectal cancer surgery is still underestimated by physicians.[9]

In order to improve patient education and decision-making on this topic, a balanced choice considering morbidity and oncological results, together with more knowledge about QoL, PA, and health status after rectal cancer surgery, is absolutely necessary.

This study's primary aim was to elucidate the effects of rectal surgery involving the pelvic floor, by evaluating the differences between a LAR and an APR, in terms of their PA level, QoL, and health status, among long-term rectal cancer survivors. We have hypothesized that due to less invasive surgery involving the pelvic floor, patients after a LAR could report a higher PA level, QoL, and health status compared to patients who underwent an APR.

Materials and Methods

Setting and Participants

The data from a longitudinal, prospective population-based survey among colorectal cancer survivors, some 1–11 years after their diagnosis, was used. The details of the data collection have previously been reported.[10] In short, the data collection was performed within PROFILES (Patient Reported Outcomes Following Initial Treatment and Long Term Evaluation of Survivorship). All of the individuals from the southern region of the Netherlands that were diagnosed with colorectal cancer from 2000 to 2009 as registered in the Netherlands Cancer Registry (NCR) were eligible for participation in the study.[11] The NCR records register all newly diagnosed cancer patients.

Those with unverifiable addresses, those with cognitive impairment, those who had died prior to the start of this study or who were terminally ill, those with stage 0/carcinoma in situ, and those who had already been included in the 2009 study, or another study, were excluded. The study started in December 2010 (T1) and the participants received subsequent questionnaires in 2011 (T2) and 2012 (T3). For the present study, the researchers only selected patients suffering from rectal cancer. This study was approved by a local Dutch Certified Medical Ethics Committee. All of the patients gave their informed consent.

Data Collection

The survivors were invited to participate in the study through a letter from their ex-attending specialist. This letter contained a link to a secure website, with a login name and a password. The participants could also request paper-and-pencil versions by returning a postcard that was added to the letter.

Sociodemographic and Clinical Characteristics

The survivor's sociodemographic and clinical information (i.e., tumor stage, tumor differentiation grade, type of surgery (including APR vs. LAR), chemotherapy, and radiotherapy) was available from the NCR. Unfortunately, within the prospective PROFILES' database, there was no registration of their postoperative complications (e.g., anastomotic leakages). All of the chemotherapy and the radiation therapies were administered in a neoadjuvant setting. Comorbidity at time of the study was assessed with the adapted Self-Administered Comorbidity Questionnaire.[12] Questions on marital status, educational level, current occupation, and ostomy situation (e.g., never had one, temporary but now closed, a permanent one) were obtained via self-reporting.

Quality of Life

The European Organization for Research and Treatment of Cancer (EORTC) Quality of Life Questionnaire (QLQ) C30 (Version 3.0) was used for assessing cancer-specific QoL.[13] It contains five functional scales, a global health status/QoL scale, three symptom scales, and six single items. Each item is scored on a 4-point Likert scale, except for the global health status/QoL scale, which is scored on a 7-point Likert scale. All scores were linearly transformed into a 0–100 scale,[14] whereby higher scores indicate a better level of functioning and more symptoms. In this questionnaire, physical functioning is assessed inquiring patients about their independency in daily activities, such as carrying a grocery bag, or in their need for help with the activities of daily living. Role functioning was defined as to what extent the patients' everyday work and their hobby activities were limited. Social functioning was defined as to what extent the patients' social life was disrupted.

Disease-Specific Health Status

Patients' disease-specific health status was assessed by using the EORTC QLQ-CR38 Questionnaire.[15] It consists of two multi-item scales, two single-item scales, seven symptom scales, and an item on weight loss. The items are scored on a 4-point Likert scale. All scales were linearly converted into a 0–100 scale. Again, higher scores indicate a better level of functioning and more symptoms.

Physical Activity

The validated European Prospective Investigation into Cancer (EPIC) Physical Activity Questionnaire was used in order to assess patients' PA level.[16] Participants were asked to indicate how many hours per week they spent on the following activities: walking, bicycling, gardening, housekeeping, and sports. Additionally, participants could specify six separate sports and the time that they spent on these sports in an open-ended question. In order to assess their moderate to vigorous physical activity (MVPA), metabolic equivalent intensity (MET) values were assigned to each activity, according to the Compendium of Physical Activities.[17,18] Their total MVPA was calculated by summing the hours per week that they spent on walking, bicycling, gardening, and other various sports (≥ 3 MET).

Statistical Analyses

Differences in sociodemographic and clinical variables between patients who had undergone an APR versus a LAR were examined by using the independent sample *t* test for continuous variables and the chi-square test for the categorical variables.

In order to examine the baseline differences between an APR and a LAR on the outcome measures (PA, QoL, and health status), cross-sectional analyses were conducted first, in which the PA level, the EORTC QLQ-C30, and the EORTC QLQ-CR38 mean scores at T1 were compared, between participants who had undergone a LAR and those who had undergone an APR, by using an analysis of covariance (ANCOVA).

Secondly, longitudinal analyses were conducted to examine the differences in PA level, QoL, and health status, between APR and LAR patients, across a 3-year period. In this way, the researchers were able to analyze as to what extent the patients had recovered from their surgery. Patients who had completed at least two questionnaires were included in these longitudinal analyses. The differences between an APR and a LAR on the outcome measures that were measured at T1, T2, and T3 were analyzed by using linear mixed models (LMM), with a maximum likelihood estimation and an unstructured covariance matrix, with a two-level structure (i.e., repeated time points [lower level], patients [higher level]). In this model, an interaction between LAR versus APR and the time since diagnosis was added, in order to examine whether the effects of the type of surgery (an APR or a LAR) were different, based upon the years since diagnosis. When the interaction term was significant, the investigators stratified the LMM for the time since diagnosis: 1–4 years vs. ≥ 5 years, in which the time since diagnosis was rounded off. When the interaction term was not significant, the interaction term was removed from the LMM, allowing for the interpretation of the main effects of the APR vs. the LAR procedures.

In order to isolate the effects of the surgery that involve the pelvic floor and in order to minimize the confounding factors that are attributed to the presence of an ostomy, subanalyses were performed, comparing the differences in PA level, QoL, and health status, across time between patients who had undergone an APR and those who had undergone a LAR, after having received a permanent ostomy. For these subanalyses, similar longitudinal analyses were performed. Sociodemographic and clinical variables were analyzed as time-invariant predictors (i.e., the baseline characteristics were used). Confouding background variables that are known to impact PA level, QoL, and health status, that is, sex, age at diagnosis, years since diagnosis, cancer stage, comorbidity, martial status, and educational level, were included. A p value < 0.05 was regarded as statistically significant and all analyses were performed using SPSS 22 (IBM SPSS, Version 22.0). Clinically relevant differences for the EORTC QLQ-C30 questionnaire were determined according to the guidelines as suggested by Cocks et al.[19] For the EORTC QLQ-CR38 questionnaire, clinically relevant differences were based on Norman's "rule of thumb" of half a standard deviation.[20]

Results

Sociodemographic and Clinical Characteristics

At T1, the response rate of the rectal cancer survivors was 75% ($N = 905$). Of this group, 62% ($N = 632$) had undergone a LAR, while 27% ($N = 273$) had undergone an APR (Table 1). The median time of follow-up was 5.1 years after their surgery. At T1, the LAR patients were less often treated with radiotherapy (94% vs. 75%, respectively, $p < 0.001$), when compared to the APR patients. No other differences in sociodemographic and clinical characteristics were found. At T1, LAR patients with a permanent ostomy had a slightly higher age (70.8 vs. 68.2, $p = 0.02$) and, again, were less often treated with radiotherapy (94% vs. 83%, $p = 0.001$), when compared to APR patients.

Among patients who had undergone a LAR, 25% ($N = 135$) had received no ostomy, 58% ($N = 320$) had a temporary ostomy that was reversed, and 17% ($N = 94$) had a permanent

Table 1 Sociodemographic and clinical characteristics at T1 of rectal cancer survivors stratified by APR vs. LAR

	All respondents ($n = 905$)	APR ($n = 273$)	LAR[a] ($n = 632$)	LAR with a permanent ostomy ($n = 94$)	p value[b]	p value[c]
Sociodemographic characteristics						
Age at time of survey (mean (SD))	68.3 (9.5)	68.2 (9.6)	68.4 (9.5)	70.8 (9.0)	0.80	0.02
Sex (female)	368 (41%)	100 (37%)	268 (43%)	31 (33%)	0.10	0.52
Partner (yes)	706 (78%)	215 (79%)	491 (78%)	74 (79%)	0.77	0.95
Educational level[d]					0.10	0.92
Low	420 (47%)	136 (50%)	284 (46%)	47 (50%)		
Middle	290 (32%)	92 (34%)	198 (32%)	30 (32%)		
High	187 (21%)	45 (17%)	142 (23%)	17 (18%)		
Employment (yes)	164 (19%)	49 (19%)	115 (19%)	11 (12%)	0.99	0.13
Clinical characteristics						
Number of comorbid conditions					0.23	0.48
None	240 (29%)	62 (25%)	178 (31%)	21 (25%)		
One	246 (30%)	78 (31%)	168 (29%)	32 (38%)		
Two or more	347 (42%)	111 (44%)	236 (41%)	32 (38%)		
Years since diagnosis (mean (SD))	5.5 (2.7)	5.4 (2.6)	5.5 (2.8)	4.9 (2.7)	0.46	0.14
					0.89	0.10
Years since diagnosis	444 (49%)	133 (49%)	311 (49%)	55 (59%)		
1–4	461 (51%)	140 (51%)	321 (51%)	39 (42%)		
≥ 5						
Stage					0.84	0.89
1	348 (40%)	108 (42%)	240 (39%)	43 (46%)		
2	257 (29%)	73 (28%)	184 (30%)	25 (27%)		
3	243 (28%)	68 (27%)	175 (28%)	23 (25%)		
4	26 (3%)	8 (3%)	18 (3%)	2 (2%)		
Tumor grade					0.12	0.39
Well differentiated	37 (6%)	5 (3%)	32 (7%)	3 (5%)		
Moderately differentiated	513 (82%	141 (83%)	372 (82%)	54 (87%)		
Poorly differentiated	76 (12%)	24 (14%)	52 (11%)	5 (8%)		
Chemotherapy (yes)	220 (24%)	63 (23%)	157 (25%)	19 (20%)	0.57	0.57
Radiotherapy (yes)	728 (80%)	257 (94%)	471 (75%)	78 (83%)	< 0.001	0.001

APR, abdominoperineal resection; *LAR*, low anterior resection; *SD*, standard deviation

[a] The LAR group includes *all* patients who have undergone a LAR, including those with a permanent ostomy

[b] p values represent comparison between APR patients and LAR patients, including those with a permanent ostomy

[c] p values represent comparison between APR patients and LAR patients who have a permanent ostomy

[d] Education: low (no or primary school); medium (lower general secondary education or vocational training); high (pre-university education, high vocational training, university)

ostomy. The response rate of the rectal cancer survivors at T2 was 83% ($N = 665$), and at T3, it was 84% ($N = 597$).

APR Versus LAR at T1

At T1, no significant differences were found in their PA level between patients who had undergone an APR and a LAR (10.6 vs. 11.4; $p = 0.2$). With respect to their QoL, the patients who had undergone an APR reported a worse PA level (77.6 vs. 81.6; $p = 0.009$) and role functioning (77.2 vs. 81.4; $p = 0.03$), as well as more insomnia (22.0 vs. 19.2; $p = 0.03$) and financial problems (9.8 vs. 6.6; $p = 0.04$), but less constipation (6.0 vs. 10.2; $p = 0.02$) (Fig. 1). Regarding their disease-specific health status, they also reported a worse body image (75.8 vs. 82.0; $p = 0.001$) and fewer gastrointestinal problems (14.0 vs. 16.8; $p = 0.009$), but more male sexual problems (52.0 vs. 60.0; $p = 0.03$).

APR Versus LAR—Did the Time After Surgery Influence Their Outcomes?

The longitudinal analyses were based on the APR and LAR patients who had completed at least two questionnaires ($N = 633$; APR = 204, LAR = 429). Differences in sociodemographic and clinical characteristics at T1, between those patients who had completed one or more than one questionnaire, are presented in Table 2.

In the longitudinal analyses, the researchers examined the effects of the type of surgery (an APR vs. a LAR) on the outcome measures (i.e., PA level, QoL, and health status), across the three yearly measurements. No significant differences were found in their PA level between the patients who had undergone an APR vs. a LAR. However, those who had undergone an APR did report a worse physical functioning, a poorer body image, and more male sexual problems, but less sexual enjoyment, constipation, diarrhea, gastrointestinal problems, and stoma-related problems (Table 3). These differences did not change over time after their diagnosis. As problems are most prevalent in the very first few months or years after surgery, post hoc analyses were conducted, when stratifying for < 2.0 versus ≥ 2.0 years after their diagnosis. Indeed, among those who were diagnosed < 2.0 years ago ($N = 43$), APR patients ($N = 13$) reported a better role and social functioning, a better global health status, and less dyspnea, when compared to their counterparts who had undergone a LAR ($N = 30$). Among those that were diagnosed ≥ 2.0 years ago, these differences were no longer significant (Table 3).

Subanalyses: APR Versus LAR with a Permanent Ostomy

Comparative longitudinal analyses were conducted between patients who had undergone an APR ($N = 204$) and patients from the LAR group who had received a permanent ostomy ($N = 56$) (Table 4). No significant differences were found in their PA level and their physical functioning. However, patients who had undergone an APR did report a better body image, a better future perspective, and fewer nausea/vomiting and stoma-related problems. Furthermore, the results of the longitudinal analyses showed that some effects differed for the amount of time after their diagnosis. Specifically, patients who had undergone an APR 1–4 years ago reported a better emotional functioning, together with an improved social functioning and global health status, when compared to their LAR counterparts. However, among those that were diagnosed ≥ 5 years ago, these differences between those who had undergone an APR and a LAR were no longer significant. In addition, among this particular groups, APR patients reported more dyspnoea, while among those that were diagnosed < 5 years, these differences were not significant.

Discussion

The primary aim of this population-based study of over 900 rectal cancer survivors 1–11 years after diagnosis was to evaluate their PA level, QoL, and disease-specific health status after surgery (APR vs. LAR), as well as to assess the influences of their pelvic floor dissections. The results showed no differences in their self-reported PA level between patients who had undergone an APR and a LAR. Moreover, no differences in PA levels were found between APR patients and LAR patients with a permantent ostomy. With respect to QoL, results from both the cross-sectional and the longitudinal analyses showed that physical functioning seemed to be worse in the APR patients.

One important confounding factor in both analyses was the presence of an ostomy. In order to elucidate the effects of surgery on the pelvic floor, patients who had undergone an APR were compared to patients who had undergone a LAR with a permanent ostomy. However, selection bias could be a contributing factor. APR patients received neoadjuvant radiotherapy, more often than LAR patients, which might have resulted in more radiotherapy-related morbidity (e.g., pain, urinary problems).[21] In addition, patients who received a permanent ostomy might have already been in a worse overall condition at time of surgery. This might have made them less attractive for the creation of an anastomosis, given the risk of more severe complications. However, at baseline, no differences were found in comorbid conditions between the APR group, the LAR group, and the LAR group with a permanent ostomy.

Orsini et al.[22] described in an earlier study that there was no impairment from an ostomy on the QoL after rectal surgery; their primary aim was to evaluate the effects of an ostomy on QoL. This current study's intent was to evaluate PA level,

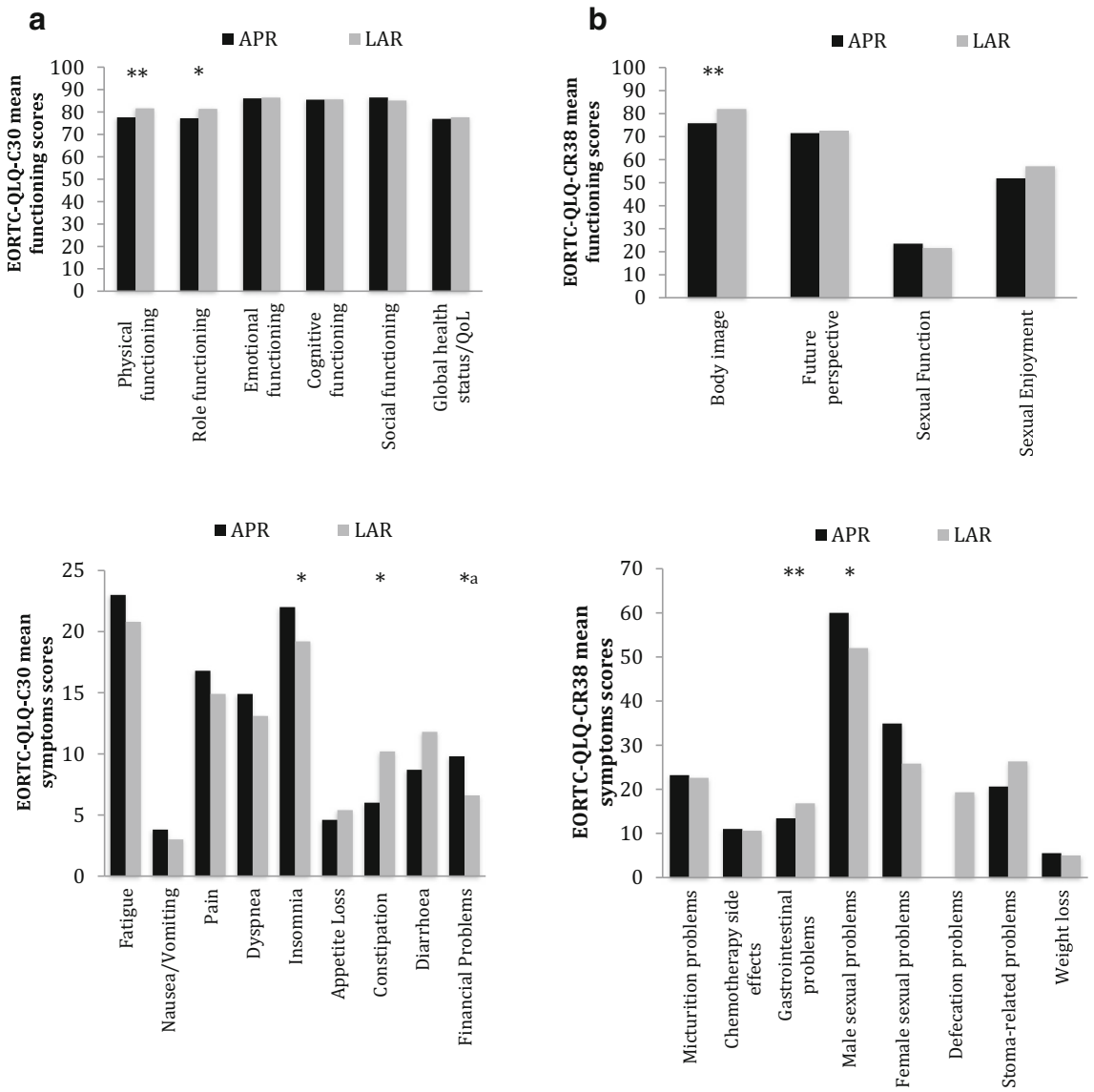

Fig. 1 (A) Differences on EORTC QLQ-C30 mean functioning (upper), global quality of life (upper), and symptom scores (below) at T1 between rectal cancer survivors who had undergone an APR ($N = 273$) and those who had undergone a LAR ($N = 632$). A higher score on the functional and global QoL scales means better functioning and QoL, while a higher score on the symptom scales means more complaints. *$P < 0.05$; **$P < 0.01$. [a]Clinically relevant differences were determined according to the guidelines by Cocks et al.[19] Differences found were all of small clinical relevance. (B) Differences on EORTC QLQ-CR38 mean functioning (upper) and symptom scales (below) between rectal cancer survivors who had undergone an APR ($N = 273$) and those who had undergone a LAR ($N = 632$). A higher score on the functional scales means better functioning, while a higher score on the symptom scales and weight loss item means more complaints. * $P < 0.05$; ** $P < 0.01$. Clinically relevant differences were based on Norman's rule of thumb.[20] None were found.

QoL, and health status after rectal surgery; therefore, the researchers made a distinction between the two different surgical procedures (an APR or a LAR).

With respect to QoL, there were several differences in role functioning, social functioning, and global health, between patients who had undergone their LAR more recently. Specifically, the LAR patients' everyday work and hobby activities were limited (role functioning), their social life was disrupted (social functioning), and their overall condition was poorer (global health status) to a greater extent, when compared to those patients who had undergone an APR. However, these effects were no longer significant among those that were diagnosed ≥ 2 years ago. These changes in role functioning, which recover over time, are somewhat in line with findings of Hamaker et al.[23] Similar findings were found when the researchers compared the APR group with LAR patients who had received a permanent ostomy. However, these effects were still visible among those that were diagnosed less than 5 years ago.

Several factors can be thought of that underlie these findings. Firstly, all patients who plan to undergo an (non-sphincter-sparing) APR will receive a permanent ostomy. Therefore,

Table 2 Sociodemographic and clinical characteristics at T1 of rectal cancer survivors who have undergone a LAR or an APR and who completed one or two or more questionnaires

	Responders who completed only one questionnaire ($N = 277$)	Responders who completed ≥ two questionnaires ($N = 633$)	p value
Sociodemographic characteristics			
Age at time of survey (mean (SD))	70.8 (8.9)	67.3 (9.5)	< 0.001
Sex (female)	123 (44%)	250 (40%)	0.17
Partner (yes)	203 (75%)	502 (80%)	0.09
Educational level[a]			0.001
Low	152 (56%)	268 (43%)	
Middle	74 (27%)	216 (35%)	
High	44 (16%)	142 (23%)	
Employment (yes)	29 (11%)	135 (22%)	< 0.001
Clinical characteristics			
Number of comorbid conditions			0.46
None	67 (28%)	173 (29%)	
One	64 (27%)	182 (31%)	
Two or more	106 (45%)	240 (40%)	
Years since diagnosis (mean (SD))	5.8 (2.7)	5.3 (2.7)	0.03
Stage			< 0.001
1	109 (40%)	242 (40%)	
2	77 (28%)	182 (30%)	
3	67 (25%)	176 (29%)	
4	19 (7%)	7 (1%)	
Tumor grade			0.25
1	8 (4%)	29 (7%)	
2	157 (81%)	360 (82%)	
3	28 (15%)	48 (11%)	
Chemotherapy[b] (yes)	65 (24%)	155 (25%)	0.74
Radiotherapy[b] (yes)	220 (79%)	513 (81%)	0.57

APR, abdominoperineal resection; *LAR*, low anterior resection; *SD*, standard deviation

[a] Education: low (no or primary school); medium (lower general secondary education or vocational training); high (pre-university education, high vocational training, university)

[b] All patients underwent at least surgery

Table 3 Linear mixed models comparing APR vs. LAR patients on physical activity, EORTC QLQ-C30, and EORTC QLQ-CR38 scores across time

	APR vs. LAR		
	Estimate	SE*	p value
Physical activity			
Physical activity (≥ 3 METs)	− 0.64	0.7	0.35
EORTC QLQ-C30			
Physical functioning	− 3.68	1.4	0.009
Role functioning			
< 2.0 years after diagnosis	11.74	5.7	0.045
≥ 2.0 years after diagnosis	− 2.51	2.0	0.21
Emotional functioning	0.79	1.4	0.58
Cognitive functioning	2.14	1.5	0.15
Social functioning			
< 2.0 years after diagnosis	17.3	6.5	0.01
≥ 2.0 years after diagnosis	− 0.30	1.6	0.85
Global health status			
< 2.0 years after diagnosis	12.79	4.0	0.003
≥ 2.0 years after diagnosis	− 0.49	1.4	0.72
Fatigue	1.54	1.7	0.36
Nausea and vomiting	− 0.90	0.8	0.27
Pain	− 0.90	1.7	0.60
Dyspnea			
< 2.0 years after diagnosis	− 11.27	4.0	0.008
≥ 2.0 years after diagnosis	2.76	1.8	0.13
Insomnia	1.65	2.0	0.42
Loss of appetite	0.38	1.0	0.70
Constipation	− 5.56	1.5	< 0.001
Diarrhea	− 5.24	1.5	< 0.001
Financial impact	− 2.08	1.4	0.13
EORTC QLQ-CR38			
Body image	− 5.76	1.9	0.002
Future perspective	2.73	2.0	0.17
Sexual function	0.63	1.8	0.72
Sexual enjoyment	− 6.28	3.0	0.04
Micturition problems	0.30	1.3	0.82
Chemotherapy side effects	0.87	1.0	0.40
Gastrointestinal problems	− 4.40	1.1	< 0.001
Male sexual problems	9.81	3.7	0.008
Female sexual problems	7.31	6.46	0.26
Stoma problems	− 10.81	2.3	< 0.001
Weight loss	0.62	1.0	0.55

*Standard error

Estimates: regression coefficients of the dependent variable for APR patients ($N = 204$) compared to LAR patients ($N = 429$) (reference group). A negative estimate indicates that APR patients have a lower score on the specific outcome measure, compared to LAR patients. A higher score on the EORTC QLQ-C30 and EORTC QLQ-CR38 functional scales, a higher score on the EORTC QLQ-C30 global QoL scale, and a higher physical activity score mean better functioning, QoL, and physical

any preoperative preparations and education must be focused on an outcome with an ostomy. On the contrary, in patients who are preparing for a LAR, the creation of an ostomy is not certain. When the creation of an ostomy is necessary, due to their poor overall condition, multiple comorbid conditions or postoperative complications (i.e., an anastomotic leakage) will be present. Hereby, the creation of an ostomy will be a

activity level, respectively. A higher score on the EORTC QLQ-C30 and EORTC QLQ-CR38 symptom scales and the EORTC QLQ-CR38 weight loss item means more complaints

Scale ranges from 0 to 100

Covariates included sex, age at diagnosis, years since diagnosis, cancer stage, comorbidity, marital status, and educational level

disappointment and will be less expected, which might result in more time needed, in order to adapt to the new situation. This phenomenon can also contribute to the noticeable fact that APR patients report a better body image and future perspective, when compared to LAR patients with an ostomy. Consequently, patients who had undergone an APR reported fewer GI problems (constipation, stoma-related problems). The findings in this study are in accordance with those in previous studies that have shown that a LAR, or sphincter-preserving surgery, often leads to a bowel dysfunction.[24] Especially, those patients, after an anterior resection with an anastomosis, are prone to develop a condition called LARS, which involves a number of symptoms, such as frequent defecations, an urgency, and a stool incontinence.[4]

Sexual functioning has become an important patient-centered outcome. In the present study, there were significantly more male sexual problems among APR patients, although the higher rate of radiotherapy use in the APR group can also be a contributing factor here.[25,26] This is in line with earlier studies, where an APR has led to less sexual activity, together with more erectile dysfunctions in men. This can be attributed to anatomical reasons, as the pelvic floor has an important role in sexual functioning.[27,28]

This study has several limitations that should be mentioned. First, a survivorship bias could have played an important role. Only patients who were relatively healthy and who survived the treatment were included. Secondly, there was no registration of baseline PA level and QoL, so the investigators cannot rule out differences between APR and LAR patients at baseline. Nevertheless, when considering the size of this database, it can be assumed that no differences existed in the pre-treatment levels. Thirdly, postoperative complications and perioperative considerations on creating an ostomy were not included in the data collections of the survivors. Complications, such as an anastomotic leakage, can be a major influence in the decision-making process of creating an ostomy. It can contribute to the morbidity in the recovery of the patients and it can also influence long-term outcomes. Consequently, the researchers in this study cannot rule out the confounding factors that were maybe caused by the lack of registration of complications.

Despite these limitations, this study is a large population-based study with high response rates (75%). Therefore, extrapolating these results to the larger populations of rectal cancer survivors seems justified. In addition, validated and reliable questionnaires were used. Further prospective studies,

Table 4 Linear mixed models comparing APR patients with LAR patients with a permanent ostomy, on physical activity, EORTC QLQ-C30, and EORTC QLQ-CR38 scores across time

	APR vs. LAR		
	Estimate	SE*	*p* value
Physical activity			
Physical activity (≥ 3 METs)	− 0.52	1.2	0.67
EORTC QLQ-C30			
Physical functioning	2.86	2.7	0.29
Role functioning	5.00	3.6	0.16
Emotional functioning			
1–4 years after diagnosis	10.32	3.6	0.002
≥ 5 years after diagnosis	1.00	3.5	0.91
Cognitive functioning	3.37	2.4	0.15
Social functioning			
1–4 years after diagnosis	14.97	3.5	< 0.001
≥ 5 years after diagnosis	5.39	4.3	0.31
Global health status			
1–4 years after diagnosis	9.56	2.8	0.001
≥ 5 years after diagnosis	− 2.38	3.3	0.47
Fatigue	0.64	3.0	0.83
Nausea and vomiting	− 2.91	1.3	0.03
Pain	− 4.63	3.2	0.14
Dyspnea			
1–4 years after diagnosis	− 7.24	3.8	0.06
≥ 5 years after diagnosis	10.64	5.2	0.04
Insomnia	− 1.36	3.4	0.69
Loss of appetite	1.92	1.9	0.30
Constipation	− 0.10	2.2	0.97
Diarrhea	− 3.28	2.0	0.11
Financial impact	− 0.005	2.3	0.998
EORTC QLQ-CR38			
Body image	7.06	3.6	0.048
Future perspective	7.32	3.7	0.048
Sexual function	2.50	3.3	0.45
Sexual enjoyment	− 6.96	2.5	0.21
Micturition problems	− 2.18	2.3	0.35
Chemotherapy side effects	0.22	1.9	0.91
Gastrointestinal problems	− 0.56	1.8	0.76
Male sexual problems	− 7.39	6.1	0.23
Female sexual problems	0.52	15.4	0.97
Stoma problems	− 8.44	2.5	0.001
Weight loss	1.45	1.9	0.44

*Standard error

Estimates: regression coefficients of the dependent variable for APR patients ($N = 204$) compared to LAR patients with a permanent ostomy ($N = 56$) (reference group). A negative estimate indicates that APR patients have a lower score on the specific outcome measure, compared to LAR patients with a permanent ostomy. A higher score on the EORTC QLQ-C30 and EORTC QLQ-CR38 functional scales, a higher score on the EORTC QLQ-C30 global QoL scale, and a higher physical activity

score mean better functioning, QoL, and physical activity level, respectively. A higher score on the EORTC QLQ-C30 and EORTC QLQ-CR38 symptom scales and the EORTC QLQ-CR38 weight loss item means more complaints

Scale ranges from 0 to 100

Covariates included sex, age at diagnosis, years since diagnosis, cancer stage, comorbidity, marital status, and educational level

with other ways to objectively measure outcomes, such as daily activities and functioning, are to be awaited.

Conclusion

In conclusion, no differences in the self-reported PA level between the APR patients and LAR patients were demonstrated. Physical functioning appeared to be worse when the patients had undergone an APR, but this effect was not found when comparing the APR patients with the LAR patients who had received a permanent ostomy. QoL, in terms of global health, as well as role and social functioning, was shown to be worse in LAR patients, but these worsened outcomes seem to recover over time.

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Compliance with Ethical Standards

This study was approved by a local Dutch Certified Medical Ethics Committee. All of the patients gave their informed consent. The manuscript has been prepared in accordance with the style of the journal and all of the authors have approved its contents. This manuscript is not being considered for publication elsewhere and the findings in this manuscript have not been previously published.

Conflict of Interest The authors declare that there is no conflict of interest.

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