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Outcomes on diverting ostomy formation and reversal after low anterior resection in the older more advanced rectal cancer patient

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ABSTRACT

Background: To decrease morbidity caused by anastomotic leakages after a low anterior resection (LAR) with primary anastomosis, a diverting ostomy is often created. Reversal of a diverting ostomy is associated with morbidity, which may result in non-reversal, particularly in the elderly. This study aimed to describe the diverting ostomy-related outcomes in elderly patients with more advanced rectal cancer after LAR.

Materials and methods: All rectosigmoid and rectal cancer patients ≥70 years who underwent LAR with primary anastomosis between 2006 and 2019 in the Catharina Hospital (Eindhoven, The Netherlands) were included for analyses. Reversal rates, ostomy-related complications, morbidity and mortality after ostomy reversal, and definitive ostomy rates were evaluated.

Results: In total 164 patients were included, of which 150 (91.5%) underwent primary or secondary ostomy creation. Ostomy-related complications were reported in 34.7% (95%-CI 27.1–42.9%). In total, 72.5% (95%-CI 64.2–79.7%) reversed their diverting ostomy. Non-reversal was mostly due to relapsing disease (52.6%). Median time to ostomy reversal was 3.2 months (IQR 2.3–5.0). No or minor complications after ostomy reversal were observed in 84.0% (95%-CI 75.3–90.6%). Over time, ostomy recreation was performed in 15.0% (95%-CI 8.6–23.5%), and ultimately 65.8% (95%-CI 57.8–73.2%) were ostomy-free after the median follow-up of 3.8 years.

Conclusion: Although most elderly successfully reversed their diverting ostomy after LAR with limited morbidity, attention should be paid for the risk of non-reversal and ostomy recreation over time. Preoperative patient counselling is important in every individual to be able to decide if LAR with primary anastomosis or a permanent end colostomy is preferred.

1. Introduction

In rectal cancer surgery, either a low anterior resection (LAR) or an abdominoperineal resection (APR) is performed. In patients with proximal or mid rectal cancer a low anterior resection (LAR) with or without restoration of bowel continuity is preferred. In those with very distal rectal cancer or sphincter involvement, an abdominoperineal resection (APR) is necessary, leading to a permanent end colostomy. In case a LAR is technically possible, patient characteristics such as age, physical condition, neoadjuvant treatment, sphincter function, comorbidities and perioperative findings influence the decision to create a primary anastomosis or a permanent end colostomy. A LAR with primary anastomosis is less often performed in elderly than in younger patients, probably due to concerns for both functional outcomes and the risk for anastomotic leakage [1,2].

Anastomotic leakage occurs in 11–15% of rectal cancer patients with a primary anastomosis and may have devastating consequences, especially in the elderly population [3–6]. In order to minimize the morbidity associated with an anastomotic leakage, a temporary diverting ostomy is often created [7–9]. A diverting

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ostomy is, however, associated with a risk for ostomy-related complications, which may negatively affect quality of life [8,10,11]. A diverting loop colostomy (DLC) is associated with ostomy prolapse and parastomal hernia, while a diverting loop ileostomy (DLI) is in particularly associated with the risk for high-output ostomy [12,13]. Besides, in approximately 20% of patients the diverting ostomy will not be reversed and becomes permanent [14–16]. Although studies on this topic in elderly are scarce, population-based data from the Netherlands Cancer Registry reports non-reversal rates up to 40% in elderly rectal cancer patients [11].

In order to optimize the decision-making process in elderly patients with more advanced rectal cancer that undergo rectal resection with or without restoration of bowel continuity and a protecting diverting ostomy, it is beneficial for both clinicians and patients to gain knowledge on ostomy-related outcomes.

The aim of this study was to evaluate ostomy-related outcomes in elderly patients with more advanced rectal cancer after a LAR with primary anastomosis.

2. Materials and methods

This study was conducted at the Catharina Hospital (Eindhoven, the Netherlands), a high-volume centre for the treatment of colorectal cancer (CRC) and a tertiary referral centre for advanced rectal cancer. This study was approved by the local medical ethics board (Medical Research Ethics Committees United – Nieuwegein, registration number W20.322). Patients ≥70 years treated with curative intent for rectal or rectosigmoid cancer (stage I-IV) between 2006 and 2019 were selected. The cut-off age was based on other studies describing ostomy-related outcomes in elderly patients [11]. Patients who underwent emergency resection, had locally recurrent rectal cancer or underwent previous rectal or rectosigmoid resection because of benign causes were excluded.

2.1. Treatment and definitions

Most patients in our centre had locally advanced rectal cancer and underwent neoadjuvant chemoradiotherapy (or short-course radiotherapy), according to the Dutch National Guidelines for colorectal cancer [17]. The majority of patients received a primary diverting loop colostomy (DLC), a diverting loop ileostomy (DLI) was only performed when a colostomy was technically difficult or not feasible. A primary ostomy was defined as an ostomy present before or created during LAR, and a secondary ostomy was defined as an ostomy created in an additional procedure following LAR (e.g. due to anastomotic leakage in a patient without a primary diverting ostomy). Ostomy recreation was defined as recreation of an ostomy after reversal. Preoperatively, all patients were consulted by a specialized ostomy nurse to determine the ideal location of the ostomy and to receive information about ostomy care. Before ostomy reversal was performed, the anastomotic integrity was confirmed by additional diagnostic modalities such as contrast enema or endoscopy. In line with other studies, a permanent diverting ostomy due to non-reversal was defined as a persistent diverting ostomy at 18 months after creation [18,19]. Delayed reversal was defined as reversal after more than 6 months after creation [20].

2.2. Clinical data and follow-up

Patient characteristics, data on treatment and additional clinical and demographic data were retrospectively extracted from medical records. Complications occurring in the first 30 postoperative days or before hospital discharge were scored using the Clavien-Dindo classification [21]. Follow-up data were extracted from medical records or by contacting the referring hospital or the patient's general practitioner. Follow-up was calculated as the interval between the date of surgery and last contact or death. Minimal follow-up was 12 months (if alive). Patients with a persistent diverting ostomy after 12 months were minimally followed-up until 18 months or the date of ostomy reversal (if earlier than 18 months). During follow-up, ostomy reversal, ostomy-related complications, ostomy recreation and the development of local recurrence and distant metastases were recorded. The Municipal Administrative Databases were consulted to obtain information on survival data.

2.3. Statistical analyses

Statistical analyses were performed using SPSS Statistics 25.0 software (IBM, Endicott, NY, USA). The primary endpoint was the proportion of patients that underwent ostomy reversal within 18 months since creation. Secondary endpoints were ostomy-related complications, morbidity and mortality after ostomy reversal, ostomy recreation rates and definitive ostomy rates. Proportions were calculated for the whole population and 95% Confidence Intervals (95%-CI) were calculated using Clopper-Pearson interval for the primary and secondary endpoints. To determine differences between patients 70–74 and ≥75 years, comparisons between proportions were also stratified for age. Intergroup comparisons were analyzed using chi-squared test or Fisher's exact test, when appropriate, for non-continuous data. Independent *t*-tests or one-way ANOVA were used for normally distributed continuous data, and Mann-Whitney *U* tests or Kruskal-Wallis test were used for non-normally distributed continuous data, when appropriate. A *p*-value of <0.05 was considered statistically significant. All tests were two-sided. Ostomy reversal and definitive ostomy rates were calculated using the Kaplan-Meier method. Ostomy reversal rates were stratified by age group and compared using the log-rank test. Definitive ostomy rates were calculated since the date of ostomy creation. The specific causes for non- or delayed reversal and ostomy recreation were analyzed.

3. Results

In total 363 patients ≥70 years underwent curative rectal cancer surgery with LAR or APR between 2006 and 2019 (43 LAR without primary anastomosis, 156 APR and 164 LAR with primary anastomosis). Patients that underwent LAR without the formation of a primary anastomosis were significantly older than patients that underwent APR or LAR with primary anastomosis (79.4 vs. 76.2 vs. 75.0 years, $p < 0.001$). No significant differences were observed in comorbidities and ASA classification between these treatment groups. Of the 43 patients that underwent LAR without a primary anastomosis, in 23 patients the decision was made preoperatively based on preexistent incontinence, patient preferences or patient and treatment characteristics (e.g. age or neoadjuvant treatment). In the other 20 patients the decision was made during surgery based on low tumour height, pelvic fibrosis or the suspicion of insufficient blood supply to the anastomosis. As no primary anastomosis was performed, these patients were excluded from any further analyses on diverting ostomy-related outcomes.

This resulted in 164 patients that underwent LAR with primary anastomosis that were included for analysis, of which 94 (57.3%) patients were 70–74 years and 70 (42.7%) patients were ≥75 years old. Median follow-up was 3.8 years. Comorbidities were present in 79.9% of patients and were comparable between both age groups ($p = 0.29$). Clinical and demographic characteristics are presented in Table 1.

Table 1
Demographic, clinical and tumour characteristics of rectal cancer patients (n = 164), stratified by age (70–74 and ≥ 75 years).

	70–74 years	≥75 years	*p*-value
	n = 94	n = 70	
	n (%)	n (%)	
Mean age in years at time of surgery (±SD)	72.2 (1.4)	78.7 (3.0)	<0.001
Median follow-up in years (IQR)	4.4 (2.5–6.6)	3.3 (1.8–4.9)	0.03
Male	53 (56.4)	46 (65.7)	0.23
Comorbidity			0.29
None	23 (24.5)	10 (14.3)	
1 comorbidity	24 (25.5)	21 (30.0)	
2 comorbidities	21 (22.3)	13 (18.6)	
≥3 comorbidities	26 (27.7)	26 (37.1)	
ASA classification			0.053
I-II	80 (85.1)	51 (72.9)	
III	14 (14.9)	19 (27.1)	
Tumour stage (clinical)			0.06
I–II	30 (31.9)	35 (50.0)	
III–IV	61 (64.9)	34 (48.6)	
Missing	3 (3.2)	1 (1.4)	
Neo-adjuvant treatment			0.15
None	11 (11.7)	13 (18.6)	
Short course radiotherapy (5 × 5 Gy)	27 (28.7)	28 (40.0)	
Chemoradiation	51 (54.3)	27 (38.6)	
Other	5 (5.3)	2 (2.9)	
Type of LAR			0.12
Open surgery	80 (85.1)	54 (77.1)	
Transanal TME	4 (4.3)	1 (1.4)	
Laparoscopic surgery	10 (10.6)	15 (21.4)	
Conversion to open surgery	1 (1.1)	6 (8.6)	0.04
Extended (multivisceral) resection	38 (40.4)	23 (32.9)	0.32
Intraoperative treatment			
Hyperthermic intraoperative peritoneal chemotherapy	2 (2.1)	–	0.51
Intraoperative radiotherapy	39 (41.5)	17 (24.3)	0.02
Radical resection (R0)	91 (96.8)	65 (92.9)	0.29

In 145 of 164 (88.4%) patients a diverting ostomy was constructed during primary surgery, 127 (87.6%) of these were DLC and 18 (12.4%) were DLI. Of the 19 patients without a primary diverting ostomy, a secondary ostomy was created in 5 patients, of which in 4 a DLC and in 1 a permanent end colostomy was created. Anastomotic leakage was the cause for secondary ostomy creation in all of these patients. In 2 of the 145 patients with a primary diverting ostomy, a permanent end colostomy was created secondarily in the postoperative period, either due to bowel perforation and anastomotic leakage. In Fig. 1 a flowchart on patient selection and ostomy creation is presented.

After the postoperative period, 147 patients had a primary or secondary diverting ostomy and 3 had a permanent end colostomy. Ostomy-related complications were observed in 34.7% (95%-CI 27.1–42.9%). In Table 2 ostomy-related complications are described in more detail.

Postoperative anastomotic leakage or presacral abscess was observed in 16.5% of patients. Supplementary Table 1 presents the treatment of patients with anastomotic leakage or presacral abscess. In total, 8 (4.9%) patients died due to postoperative complications, of which 7 had a diverting ostomy and 1 an end colostomy. These patients were excluded from further analyses, along with 2

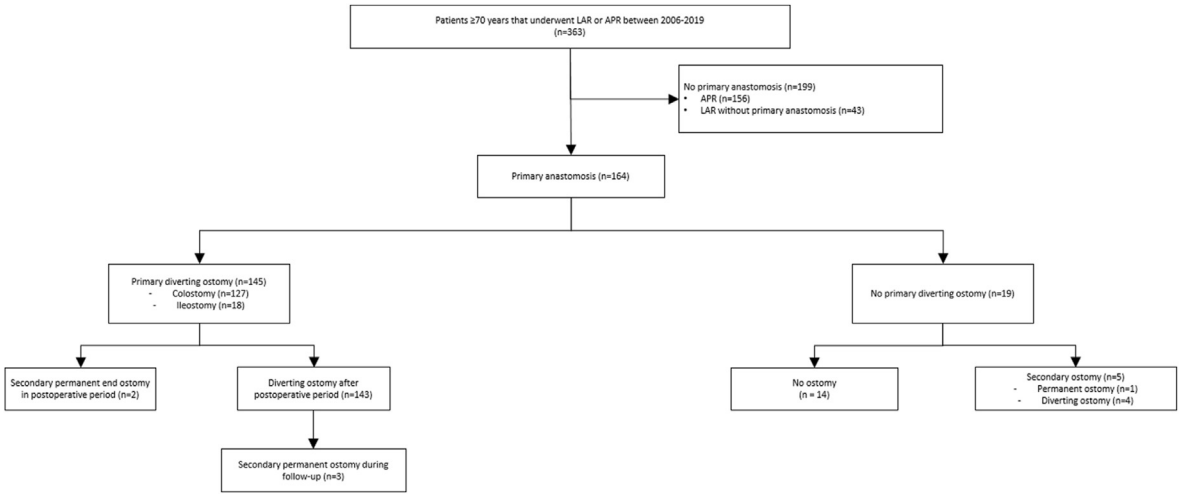

Fig. 1. Patient disposition flowchart of all elderly (≥70 years) rectal cancer patients that underwent surgery with curative intent between 2006 and 2019 (n = 363).

Table 2
Details on ostomy-related complications reported by patients with an ostomy, either primary or secondary, after low anterior resection with primary anastomosis.

	n = 150	95%-CI
	n (%)	
None	98 (65.3)	57.1–72.9
Peristomal skin problems	25 (16.7)	11.1–23.6
Stomal obstruction	5 (3.3)	1.1–7.6
Ostomy prolapse	8 (5.3)	2.3–10.2
High-output ostomy	10 (6.7)	3.2–11.9
Parastomal hernia	7 (4.7)	1.9–9.4

Table 3
Details on postoperative outcomes of all rectal cancer patients (n = 164) after low anterior resection with primary anastomosis.

	n = 164
	n (%)
Median admission time in days (IQR)	8.5 (6.0–15.0)
Median admission on ICU in days (IQR)	1.0 (0.0–2.0)
Complication Grade according to Clavien-Dindo	
None	50 (30.5)
Grade I-II	76 (46.3)
Grade IIIa+IIIb	20 (12.2)
Grade IV	10 (6.1)
Grade V	8 (4.9)
Surgical complications	
Anastomotic leakage/presacral abscess	27 (16.5)
Clavien-Dindo ≥III	13 (7.9)
Intra-abdominal abcess	6 (3.7)
Clavien-Dindo ≥III	4 (2.4)
Ileus	27 (16.5)
Clavien-Dindo ≥III	3 (1.8)
Fascial Dehiscence	7 (4.3)
Wound infection	17 (10.4)

patients that were lost to follow-up. In Table 3 details on postoperative outcomes after low anterior resection with primary anastomosis are presented.

3.1. Diverting ostomy reversal

Of the remaining 138 patients with a diverting ostomy, 72.5% (95%-CI 64.2–79.7%) reversed their ostomy successfully, with no significant differences between patients 70–74 and ≥ 75 years (74.1% vs. 70.2%, $p = 0.61$). Median time until reversal was 3.2 months (IQR 2.3–5.0). Fig. 2 presents a Kaplan-Meier curve on diverting ostomy reversal rates, stratified by age groups. Non-reversal of the ostomy occurred in 38 patients, mostly due to relapsing disease. Details on the reasons for non-reversal are presented in Table 4.

After ostomy reversal, median time of hospital admission was 3.0 days (IQR 3.0–4.0). The majority of patients had no or minor (Grade 0-II) complications (84.0% [95%-CI 75.3–90.6%]). Severe complications (Grade ≥IIIB) occurred in 8.0% (95%-CI 3.5–15.2%). Postoperative complications did not significantly differ between age groups. Table 5 presents further data on ostomy reversal and hospital admission.

3.2. Ostomy recreation and ostomy-free survival

During follow-up, 15 of 100 (15.0% [95%-CI 8.6–23.5%]) patients that reversed their diverting ostomy underwent ostomy recreation. Median time from reversal to recreation was 16.3 months (IQR 1.4–34.1). The reasons for ostomy recreation were severe functional bowel complaints (n = 5), chronic anastomotic problems (n = 4), local tumour recurrence (n = 2), surgical complications (n = 3) and enterocutaneous fistula (n = 1).

Of all patients that underwent LAR with primary anastomosis, 69.5% (95%-CI 61.6–76.6%) were ostomy-free at one year after primary surgery, and 65.8% (95%-CI 57.8–73.2%) after follow-up (median 3.8 years). No significant differences in definitive ostomy rates between age groups were observed. Supplementary Fig. 1 presents a Kaplan-Meier curve on definitive ostomy rates.

4. Discussion

In this study, investigating ostomy-related outcomes in more advanced elderly rectal cancer patients that underwent curative LAR with primary anastomosis, 72.5% of patients had their ostomy reversed successfully, with limited morbidity in the majority of patients. Over time, 15% of patients underwent ostomy recreation and after the median follow-up of 3.8 years, 65.8% of patients that underwent LAR with primary anastomosis were ostomy-free.

Previous studies described diverting ostomy reversal rates of 72.5–83% after LAR in patients of all ages [16,18,20,22–24]. However, data from the Netherlands Cancer Registry suggested that 68% of patients 71–80 years and 59.8% of patients ≥81 years reversed their diverting ostomy successfully, which is slightly lower compared to the reversal rates in this study [11]. The inferior reversal rates in elderly when compared with younger patients may be explained by the fear for a secondary procedure for ostomy reversal, along with earlier acceptance of a permanent diverting ostomy [16]. In this study, the main reason for non-reversal was relapsing disease (local or systemic), which is not age-dependent, and non-reversal was less often due to the patient's physical capacity, preferences or chronic anastomotic problems [25,26]. Previous studies showed that relapsing disease and older age were both associated with non-reversal of a diverting ostomy [10,16]. Besides, ostomy reversal was less often performed in patients with ASA classification ≥2, advanced rectal cancer, certain comorbidities (e.g. anemia, renal dysfunction), secondary ostomy creation and peri- and postoperative complications [10,16,23]. These factors should be incorporated during decision-making to determine whether a diverting ostomy is a feasible option for the individual patient.

Ostomy reversal is accompanied with morbidity and mortality, which may be feared by the older patient and the surgeon. Complications after ostomy reversal are described in 20–40% of patients, with severe (Grade ≥IIIb) complications occurring in 7–9% and a reported mortality rate of 0.4–3% [11,27–29]. The morbidity described in earlier studies on patients of all ages was comparable to our results. Moreover, a recent study confirmed that older age is not associated with an increased risk for morbidity after ostomy reversal [30]. However, patients should be informed about the need for a secondary procedure for ostomy reversal and the associated risk for complications before deciding to undergo a LAR with a primary anastomosis and the formation of a diverting ostomy.

In 88.4% of our patients a primary diverting ostomy was present after surgery, which is higher than the wide range of primary diversion after LAR of 15–74% reported in other studies [8,16,22,31]. As the present study was conducted in a referral centre for advanced rectal cancer cases, many included patients underwent neoadjuvant treatment followed by extensive surgery, probably contributing to the increased rates of primary diversion. The value of primary diversion in decreasing the absolute risk of anastomotic leakage is unclear, therefore the routine use of a diverting ostomy after bowel restoration is still a matter of debate. Nonetheless, the clinical outcomes of an anastomotic leakage are found to be better in patients with a primary diverting ostomy, with increased success rates of conservative treatment and less multiple organ failure

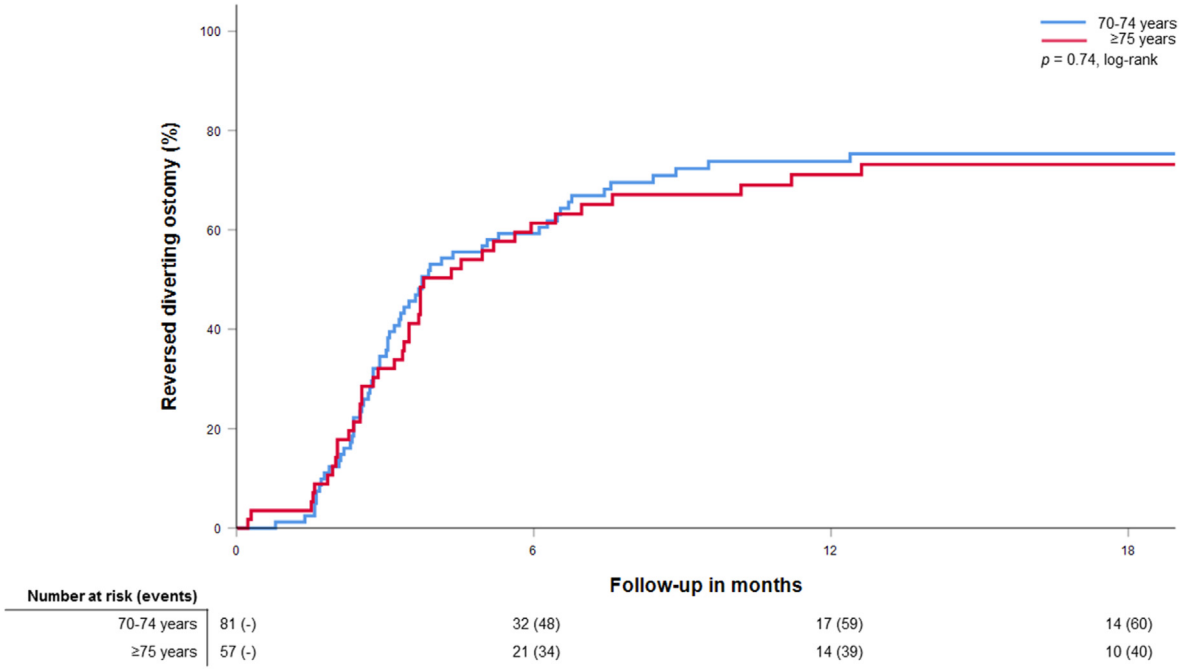

Fig. 2. Kaplan-Meier curve on diverting ostomy reversal of rectal cancer patients undergoing a low anterior resection with primary anastomosis with either a primary or secondary diverting ostomy (n = 138), stratified by age groups.

Table 4
Reasons for non-reversal at 18 months of a diverting ostomy after low anterior resection with primary anastomosis.

	n = 38
	n (%)
Relapsing disease (local/systemic)	20 (52.6)
Persistent anastomotic problems	5 (13.2)
Patient's preference	4 (10.5)
Death	1 (2.6)
Other, such as patient being unfit for surgery	5 (13.2)
Unknown	3 (7.9)

[7–9]. However, as anastomotic leakage only occurs in the minority of patients, some patients will not experience the clinical benefits, but only the potential risks related to a diverting ostomy [4–6]. Careful selecting those patients benefiting most from a diverting ostomy is essential and many studies have been performed to identify predictive factors associated with anastomotic leakage, such as age, comorbidities or neoadjuvant treatment [4,32]. In the majority of hospitals in the Netherlands, primary diversion is therefore considered standard of care after neoadjuvant treatment. Besides, elderly are more at risk for the devastating consequences

Table 5
Details on the outcomes of ostomy reversal in patients with a primary or secondary diverting ostomy (n = 100), after low anterior resection with primary anastomosis.

	n = 100	95%-CI
	n (%)	
Median time until ostomy reversal in months (IQR)	3.2 (2.3–5.0)	
Ostomy reversal <6 months	82 (82.0)	73.1–89.0
Ostomy reversal ≥6 months, reasons for delayed reversal	18 (18.0)	11.0–26.9
Persistent anastomotic problems	8 (8.0)	
Adjuvant chemotherapy or treatment of metastatic disease	4 (4.0)	
Prolonged physical recovery	2 (2.0)	
Patient's preference	1 (1.0)	
Unknown	3 (3.0)	
Median hospital admission in days (IQR)	3.0 (3.0–4.0)	
Complication grade according to Clavien-Dindo		
No complications	62 (62.0)	51.7–71.5
Grade I-II	22 (22.0)	14.3–31.4
Grade IIIA + IIIB	8 (8.0)	3.5–15.2
Grade IV	1 (1.0)	0.0–5.4
Missing	7 (7.0)	
Complications		
Surgical site infection	8 (8.0)	3.5–15.2
Anastomotic leakage	3 (3.0)	0.6–8.5
Ileus/Gastroparesis	16 (16.0)	9.4–24.7
Missing	7 (7.0)	

of an anastomotic leakage [3,32]. Therefore, especially in the elderly with more advanced rectal cancer who require neoadjuvant treatment followed by extensive surgery, primary diversion seems beneficial. Yet, identifying the patients benefitting most from a diverting ostomy still seems important.

Intestinal diversion may be performed by a DLC or DLI and the decision often depends on the surgeon's preferences. In our hospital a DLC is standard of care, and a DLI was only performed when a colostomy was technically not feasible or when already present preoperatively. Most studies evaluating the outcomes after DLC and DLI did not show clear significant overall benefits of one over the other [12,13]. Although a DLC is associated with more ostomy prolapses, parastomal hernias and surgical wound infections, a DLI increases the risk for peristomal dermatitis and high-output ostomy [12,33]. Moreover, the readmission rate after a DLI is up to 17%, mostly due to dehydration [34,35]. Especially the elderly may be more prone for the consequences of a high-output ostomy. In fact, a recent study showed that a DLI may result in long-term renal dysfunction in elderly patients, which even persisted after ostomy reversal [36]. Therefore, it could be argued that particularly in the elderly a DLC is preferred. Especially when considering the risk of a diverting ostomy becoming permanent [16].

Functional outcomes should also be discussed during shared decision making when a LAR with primary anastomosis is considered. The low anterior resection syndrome (LARS), a cluster of symptoms including fecal incontinence and urgency after sphincter-preserving surgery, can severely impact quality of life [37,38]. Although it could be speculated that older patients have increased risks to develop LARS, most studies found no association of age [39]. In this study, 5 patients underwent ostomy recreation due to severe LARS complaints, however it may be expected that invalidating symptoms may have been present in more patients. Unfortunately, this study does not have more detailed data on functional bowel complaints.

To avoid the risk of anastomotic leakage, the need to undergo a secondary procedure for ostomy reversal, and functional bowel complaints, the avoidance of a primary anastomosis and the formation of a permanent end colostomy may be preferred in the elderly. Moreover, one third of patients eventually ends up with an ostomy after LAR with primary anastomosis, either due to a permanent diverting ostomy or ostomy recreation. Especially the latter group may be prone for a prolonged period of impaired quality of life due to severe LARS complaints or persistent anastomotic problems before ultimately deciding to undergo ostomy recreation. Furthermore, health-related quality of life seems comparable between patients with a permanent end colostomy and patients without or the general population, showing that most elderly are well able to cope with a permanent ostomy [40,41].

This study highlights that a diverting ostomy after LAR with primary anastomosis can be performed relatively safely in most older patients with almost three quarters of the patients reversing their ostomy with limited additional morbidity. However, a permanent end colostomy should be considered in every older patient with more advanced rectal cancer, since 27.5% of patients will not reverse their diverting ostomy. Besides, a further 15% undergoes ostomy recreation over time, which may even underestimate the total population of patients having severe complaints after ostomy reversal. Hence, it is essential that for every individual patient the risk of anastomotic leakage, functional bowel complaints, a secondary procedure, the potential burden of non-reversal and the risk for ostomy recreation should be weighed against the consequences of a permanent end colostomy. Counselling patients, setting the right expectations and composing a tailor-made treatment plan is therefore essential.

The strength of this study lies in the availability of many clinically relevant variables with barely missing values of a unique population in a tertiary referral centre for advanced rectal cancer. A major limitation of this study is the retrospective character of this study, which could have led to an underestimation of ostomy-related complications or ostomy recreation during follow-up. By thoroughly studying the medical records, contacting the referral hospitals and general practitioners, this was kept to a minimum. Furthermore, this study was conducted in a tertiary referral centre for advanced rectal cancer. Although we aimed to describe the elderly with more advanced rectal cancer, this could have resulted in selection bias. Future studies on functional bowel complaints and the quality of life of patients with or without a diverting or permanent ostomy are warranted to further improve patient counselling.

5. Conclusions

Almost three out of four elderly patients were able to reverse their diverting ostomy with limited additional morbidity after LAR with primary anastomosis for rectal cancer. However, a permanent end colostomy should be discussed in every older patient as approximately one third of the elderly ends up with an ostomy due to either non-reversal or ostomy recreation. Adequately counselling patients about the potential risks for anastomotic leakage, non-reversal, ostomy recreation and functional outcomes is essential to be able to conscientiously decide if LAR with primary anastomosis or a permanent end colostomy is preferred.

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CRediT authorship contribution statement

S.H.J. Ketelaers: Conceptualization, Data curation, Formal analysis, Writing – review & editing. **R.G. Orsini:** Conceptualization, Writing – review & editing. **G.A.P. Nieuwenhuijzen:** Conceptualization, Writing – review & editing. **H.J.T. Rutten:** Conceptualization, Data curation, Formal analysis, Writing – review & editing. **J.W.A. Burger:** Conceptualization, Writing – review & editing. **J.G. Bloemen:** Conceptualization, Formal analysis, Writing – review & editing.

Declaration of competing interest

All authors declare there is no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejso.2021.12.020.

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