Annals of Medicine and Surgery 34 (2018) 28–33

Contents lists available at ScienceDirect

Annals of Medicine and Surgery

journal homepage: www.elsevier.com/locate/amsu

Oncological outcomes of abdominoperineal resection for the treatment of low rectal cancer: A retrospective review of a single UK tertiary centre experience

Anwar Hussain[a,*], Fahad Mahmood[a], Andrew D.W. Torrance[a], Helen Clarke[a], Cordelia Howitt[b], Robin Dawson[a]

[a] Department of Surgery, University Hospital North Midlands, Royal Stoke University Hospital, Stoke-on-Trent, UK
[b] Department of Pathology, University Hospital North Midlands, Royal Stoke University Hospital, Stoke-on-Trent, UK

ARTICLE INFO

Keywords:
Abdominoperineal resection
ELAPE
Rectal Cancer
Neoplasia

ABSTRACT

Background: The use of abdominoperineal resection (APR) in the management of low rectal cancer has received criticism over high rates of incomplete resection due to tumour involvement at the circumferential resection margin. Extralevator abdominoperineal resection has been advocated as a means of improving complete resection. However, Extralevator abdominoperineal resection can result in increased cost, morbidity and reduced quality of life.

This study aims to assess the histological features and long-term outcomes of patients undergoing standard abdominoperineal resection and discusses the potential role of Extralevator abdominoperineal resection in this cohort.

Method: A retrospective review of a prospectively maintained database of rectal cancer patients at a single centre. Patients undergoing standard APR were included from 01/06/2007 to 31/05/2012 to allow a minimum 2-year follow-up. Data was collected on age, gender, co-morbidity, pre-operative stage, neo-adjuvant therapy, histology, recurrence and mortality.

Results: Seventy patients were identified (45 (64%) male, median age 67; (range 36–85)). 12 (17.1%) patients had a positive circumferential resection margin; 4 (6.1%) tumours were located anteriorly, 8 (11%) were located posteriorly or laterally and may potentially have been completely resected with extralevator abdomino-perineal resection, Number-needed to treat = 9. Positive circumferential resection margin was more common in advanced tumours ($p < 0.001$). Local recurrence was more common with positive circumferential resection margins (16.7% Vs 0%, $p = 0.027$), with no statistically significant difference in 5-year survival, although there was a tendency towards worse survival in these patients.

Conclusion: Positive circumferential resection margin following APR resulted in significantly increased local recurrence with a trend towards poorer survival outcomes. Extralevator abdomino-perineal resection may have benefited some of these patients with locally advanced tumours and postero-lateral recurrences. However, this has to be balanced against exposing patients to increased risk of adverse events. We would recommend selective use of Extralevator abdominoperineal resection for locally advanced and node-positive tumours although further studies to help refine selection criteria are required with long-term follow-up.

1. Introduction

The management of advanced low rectal cancer has seen significant changes over the last decade with the advent of extralevator abdominoperineal excision of the rectum (ELAPE). With concerns over incomplete resection rates in abdominoperineal resection (APR) compared to anterior resection as well as high local recurrence, ELAPE has been championed by some as a means of reducing tumour involvement at circumferential resection margins (CRM) [1–3]. By ensuring a wider resection margin ELAPE should theoretically reduce the risk of tumour involvement at the circumferential resection margin and therefore reduce incomplete resection rates [4]. This improved resection rate should in turn reduce rates of local recurrence and improve disease free and cancer specific survival.

* Corresponding author. Department of Surgery, University Hospital North Staffordshire, Newcastle Road, Stoke-on-Trent, ST4 6QG, UK.
E-mail address: anwar.hussain@doctors.org.uk (A. Hussain).

https://doi.org/10.1016/j.amsu.2018.06.007
Received 28 September 2017; Received in revised form 11 June 2018; Accepted 21 June 2018

Several studies have demonstrated reduced local recurrence in selected groups of patients undergoing ELAPE, albeit with increased rates of complication and increased cost [5–17]. The larger perineal defect left following ELAPE may require additional resources to close either with mesh, be that synthetic or biological, or complex plastic surgery [18]. ELAPE has increased morbidity; with reported complication rates of up to 50% including perineal wound breakdown and revision, perineal hernia, chronic sinus and donor site complications if myocutaneous flap reconstruction is required [2,15,19]. In addition, within both the standard APR and ELAPE the anterior resection plane remains the same. Thus despite resection of a much larger volume of tissue with ELAPE, there is no wider resection achieved in the anterior plane compared to APR [16].

This study aims to assess the rate and site of CRM positivity and its impact on disease recurrence and survival in a cohort of patients undergoing standard APR. We discuss these results in the context of procedure choice between APR and ELAPE for locally advanced low rectal cancer.

2. Materials and methods

A retrospective review of a prospectively maintained database was performed (Research Registry UIN: researchregistry3480). All operations were performed at a single, high-volume teaching hospital from 01/01/2007 to 31/06/2012. All patients were discussed pre-operatively at a specialist colorectal cancer multidisciplinary meeting and selected for APR with or without neo-adjuvant therapy as appropriate.

All patients undergoing abdominoperineal resection of the rectum for histologically proven rectal adenocarcinoma were included. Patients undergoing revisional or completion procedures or procedures with non-adenocarcinoma histology were excluded. Data was collected on age, gender, co-morbidity, neo-adjuvant therapy, histology (to include CRM positivity), recurrence and site of recurrence (Local, distant) and mortality. Local recurrence was defined as radiological or histological return of disease in the pelvic or perineum.

A consultant pathologist reviewed histology reports for each specimen and where CRM was reported positive, the CRM involvement and location was confirmed. CRM location was divided into anterior, lateral or posterior corresponding to anatomical relations within the pelvis. Patients were followed-up for a minimum of 2 and maximum of 5 years.

2.1. Surgical technique

All patients underwent ‘standard’ abdominoperineal resection either by laparoscopic or open approach. Abdominal dissection or the rectum was completed in the TME plane to the pelvic floor and then a perineal approach was used to divide the pelvic floor adjacent to the rectum and excise the anus. All procedures were performed after approval at the multi-disciplinary team meeting, by one of five consultant level surgeons with at least 5 years of consultant experience.

2.2. Data analysis

Data was analysed using SPSS 21.0 (IBM SPSS Inc. Armonk, NY, USA). Comparisons between groups were made using the chi-square test or fisher's exact test as appropriate. Binary logistic regression was performed to assess the effect of independent variables on CRM positivity. Survival was analysed using the Kaplan-Meier technique with comparison between groups made using the Log-Rank test. The effects of co-variants on survival was analysed using Cox-regression modelling. Variables were entered into the model in a stepwise method (variables were entered into the model if their associated significance level was < 0.05 and removed if significance level > 0.1). This study has been reported in compliance with strengthening the reporting of cohort studies in surgery (STROCSS) criteria [20].

3. Results

Seventy-four patients were identified from the database over the study period. 4 patients were excluded from the final analysis of which 3 patients were excluded due to squamous cell cancer histologically and one patient was excluded due to previous anterior resection of the rectum for rectal cancer who underwent a completion proctectomy for recurrence. A total of 70 patients were included in analysis. Overall, 45 (64%) patients were male with a median age of 67 years (Range 36–85 years). 56 (80%) patients received neoadjuvant therapy. 42 (60%) patients had chemo-radiotherapy (50.4 Gy (1.8 Gy in 28 fractions) combined with 5-FU over 3 months) and 14 (20%) patients had radiotherapy alone (25 Gy in 5 fractions over 5 days). 42 (60%) cases were completed via a laparoscopic approach. 4 (5.7%) cases were converted from a laparoscopic to an open approach (9.5% conversion rate) and the remaining 24 (40%) cases were performed open. All tumours were within 6 cm of the anal verge.

3.1. Circumferential resection margin positivity following abdominoperineal resection

Twelve (17.1%) patients had positive CRM at post-operative histological assessment (11 tumour involvement, 1 nodal). Of these, 4 (33.3%) patients had anterior CRM involvement, 5 (41.7%) had posterior CRM involvement and 3 (25%) patients had lateral involvement. In 2 (2.9%) patients, CRM involvement was secondary to intra-operative tumour perforation. Table 1 outlines characteristics of those patients with positive CRM (CRM+) and those without (CRM-). No significant differences were identified between the groups with respect to gender, age, use of neo-adjuvant therapy or surgical approach. CRM positivity occurred with increasing frequency with increasing stage of disease as outlined in Table 1 (Duke's stage; Chi square 21.8015, $p < 0.01$, TNM T-stage; Chi square 9.6552, $p = 0.047$).

Binary logistic regression found increased stage of disease increased the risk of CRM positivity ($p = 0.007$) as did conversion from a laparoscopic to an open operation ($p = 0.030$) when adjusted for age, gender and neo-adjuvant chemotherapy ($p = 0.003$, Table 2).

3.2. Incidence of disease recurrence

Nineteen (27.1%) patients developed either local or distant recurrence. Median time to recurrence was 381 days (Range 61–1488 days, IQR 261–933 days) (Fig. 1). 13 (22.4%) patients in the CRM-group developed recurrence compared to 6 (50%) patients in the CRM + group. Local recurrence was more common in the CRM + group (2 patients (16.7%) compared to no patients in the CRM-

Table 1
Characteristics of patients with and without circumferential resection margin (CRM) involvement. Increased stage of disease is associated with an increased incidence of CRM positivity.

	CRM+	CRM-	P value
Age (median (range))	62 (52–81)	68 (36–85)	n/s
Sex (male)	6 (50%)	40 (69%)	n/s
Neo-adjuvant therapy	8 (67%)	48 (83%)	n/s
Surgical approach (laparoscopic)	7 (58%)	35 (60%)	n/s
Dukes Stage			
- Complete response	0	6 (10.3%)	
- Dukes A	0	18 (31%)	
- Dukes B	2 (16.7%)	24 (41.4%)	
- Dukes C	10 (83.3%)	10 (17.2%)	P < 0.001
T stage			
- T0	0	7 (12.1%)	
- T1	1 (8.3%)	9 (15.5%)	
- T2	0	12 (20.7%)	
- T3	8 (66.7%)	27 (46.6%)	
- T4	3 (25%)	3 (5.2%)	P = 0.047

Table 2
Binary logistic regression of co-variables for CRM positivity shows increased stage associated with higher risk of CRM positivity.

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
Sex (Female)	−.056	.868	.004	1	.949	.946	.173	5.182
Age	−.066	.043	2.382	1	.123	.936	.861	1.018
Approach			4.661	2	.097			
- Laparoscopic	4.522	2.096	4.653	1	.031	92.031	1.511	5603.543
- Converted	.741	.963	.593	1	.441	2.098	.318	13.844
Neo-adjuvant	.841	1.063	.626	1	.429	2.320	.289	18.643
Histology			7.267	3	.064			
- CPR	−21.315	16104.190	.000	1	.999	.000	.000	.
- Dukes A	−23.067	7955.312	.000	1	.998	.000	.000	.
- Dukes B	−3.420	1.269	7.267	1	.007	.033	.003	.393
Constant	3.663	2.931	1.562	1	.211	38.979		

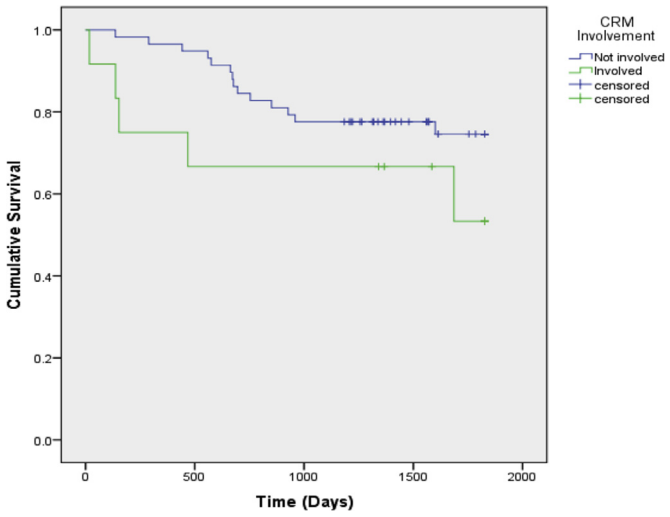

Fig. 1. Kaplan Meier curve, comparing time to cancer recurrence in patients with or without circumferential resection margin positivity.

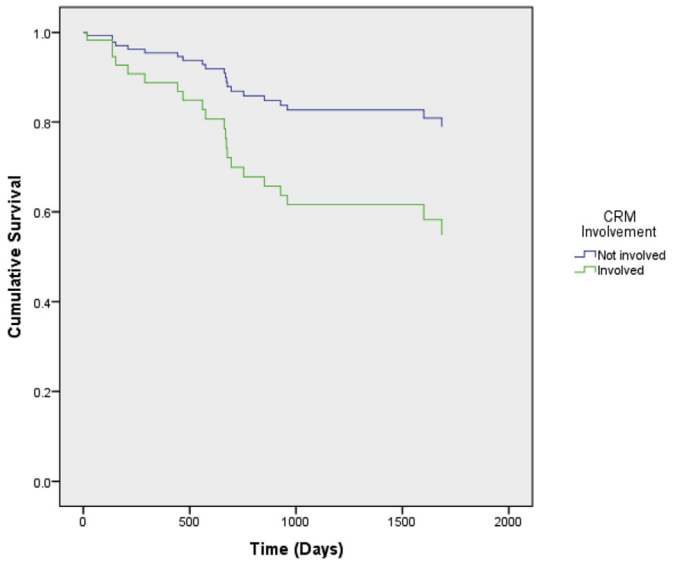

Fig. 2. Cox regression curve showing survival between patients with or without positive circumferential resection margins.

Table 3
Site of recurrence at follow-up. Patients with positive circumferential resection margins (CRM) are more likely to experience recurrence as well as distant recurrence proportionally.

CRM status	No recurrence	Local recurrence	Distant recurrence
CRM-	45	0	13 (22.4%)
CRM+	6	2 (16.7%)	4 (33.3%)

group, p = 0.030; Table 3). None of the patients with local recurrence developed distant metastases.

3.3. Survival following abdominoperineal resection for low rectal cancer

Median survival was 4 years and 4 months. No statistically significant difference was demonstrated in overall survival between those patients with an involved circumferential resection margin compared to those without (Fig. 2: Log-rank, Chi Squared 2.110, p = 0.15). Comparison was made between CRM-positive and CRM-negative patients using Cox regression analysis. Results were adjusted for age, gender, neo-adjuvant therapy and histological stage (Table 2). No significant difference was demonstrated in survival in patients with a positive circumferential margin when adjusted for gender, use of neo-adjuvant therapy or tumour stage. Advancing age was an independent risk factor for poor survival outcome (OR 1.088 [CI 1.020–1.160], p = 0.011; Table 4).

4. Discussion

In this study we investigated CRM positivity, risk of tumour recurrence and its impact on survival in patients undergoing abdominoperineal resection for low rectal cancer. We have demonstrated similar rates of CRM positivity as reported elsewhere in the literature although a wide variation exists for this figure. Klein et al. reported a CRM positive rate of 7% in their cohort compared to 20% in the Asplund et al. series whereas Kennelly and colleagues report a rate of 13.9% perhaps reflecting different patient selection criteria and thresholds for considering a more extensive resection [11,15,27]. Furthermore, through logistic regression analysis we have shown that both advanced stage of disease as well operative conversion from laparoscopic to open abdominoperineal resection increases the risk of CRM positivity. Increased risk of CRM positivity with conversion to the open approach may reflect a difficult pelvic dissection due to difficult tumour anatomy making a clean and complete dissection very difficult. This will not be helped by an open procedure with a more limited view compared to laparoscopic guidance. Consequently, positive CRM in our cohort translated to an increased incidence of local tumour recurrence. Moreover, the majority of these patients had locally advanced tumours, with Dukes C or T3-4 according to the TNM staging criteria. This finding is consistent with data from a large multicentre study by Kennelly et al. demonstrating that CRM positivity was dictated by tumour stage rather than surgical technique, with advanced tumour stage having a higher risk of CRM positivity [27]. Thus, the implication that obtaining clear resection margins may be more difficult in more advanced cancers with

Table 4
Cox regression analysis of co-variants affecting survival. Advancing age was associated with poor survival outcomes. No other factors were associated with a significant difference in survival.

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
Sex (Female)	−.338	.564	.359	1	.549	.713	.236	2.156
Age	.084	.033	6.483	1	.011	1.088	1.020	1.160
Neo-adjuvant	.193	.566	.117	1	.733	1.213	.400	3.679
Histology			5.223	3	.156			
- Dukes A	−.356	1.194	.089	1	.766	.701	.067	7.279
- Dukes B	.447	1.098	.166	1	.684	1.564	.182	13.454
- Dukes C	1.299	1.122	1.341	1	.247	3.667	.407	33.076
CRM Involvement	−.837	.746	1.259	1	.262	.433	.100	1.869

abdominoperineal resection.

Local recurrence is a potential consequence of positive CRMs with our study showing a greater proportion of patients with positive CRMs developing recurrent disease. Neoadjuvant therapy in APR reduces risk of local recurrence as demonstrated by Ramsay et al. with 3 year follow-up results for 43 patients undergoing standard APR for rectal cancer following neo-adjuvant chemoradiotherapy [33]. In our study, 80% of patients received neo-adjuvant therapy, which did not significantly affect CRM positivity or overall survival. This is likely due to earlier stage tumours in those not selected to receive neoadjuvant therapy. However, 10.3% of patients showed a complete pathological response to neoadjuvant chemo-radiotherapy and there is an argument for such responders to have surgery delayed and be observed for disease progression [35]. This remains an area of controversy and further research as radiological staging of so-called complete responders is not fully accurate and can vary depending on various imaging modalities. Hence current standards do not support a 'watch and wait' policy for such patients. In addition, tumour recurrence may negatively impact on survival. Our cohort showed a median survival of 4 years and 4 months post procedure. We did not demonstrate a statistically significant difference in survival even when adjusted for gender, neoadjuvant therapy or stage. However, the Kaplan-Meier survival curve shows a trend towards worsening survival in CRM positive patients who have undergone abdominoperineal resection, which might be significant given longer-term follow-up. The implications of these findings raise the question of whether these patients may have benefitted from a more extensive resection.

Extralevator abdominal perineal resection (ELAPE) involves resection of additional tissue lateral and posterior to standard APR resection at the pelvic floor. The use of ELAPE in the management of low rectal cancer is growing [21]. This increase is in response to reported poor surgical outcomes following standard APR when compared to anterior resection [1]. Responsibility for these poor outcomes has been in part attributed to surgical waisting around the sphincter complex resulting in incomplete resection and increasing risk of local recurrence [22]. Since Holm et al. published their report of a cylindrical APR in 2007 other studies have reported favourable results from this wider resection [1]. However, as demonstrated by Bökkerink et al., there has been a significant improvement in the care of all patients undergoing APR over the last decade regardless of surgical approach [23]. Moreover, ELAPE does not address anterior CRM involvement, nor involvement at the circumferential margin above the pelvic floor. In our cohort of patients just over a third of those with a positive CRM had involved anterior margins. With the exception of the one patient with intra-operative tumour perforation, surgery in these patients would not deliver disease free resection margins without recourse to multi-organ resection. In addition, larger cohort studies and subsequent systematic reviews have recently challenged earlier smaller studies reporting reduced CRM positive rates in ELAPE compared to APR. In a review of published data by Krishna et al., in 2013, the authors failed to demonstrate significantly lower rates of CRM positivity following ELAPE compared to standard APR and Zhou et al. in an updated systematic review of 2672 patients from 8 studies demonstrated no significant difference in CRM positivity rate [24,25]. Indeed, a recent report from the Swedish Colorectal cancer registry including 1397 patients actually demonstrated an increase in CRM positivity following ELAPE and local recurrence at 3 years follow-up [6]. This increase in CRM positivity following ELAPE has also been demonstrated by another database review from the Danish Colorectal Cancer Group [11]. In addition, some studies have encouraged caution in the use of ELAPE owing to increased morbidity from the procedure [8]. Asplund et al. demonstrated no difference in CRM positivity, survival or local recurrence between ELAPE and standard APR though patients undergoing ELAPE had longer length of stay and more perineal wound complications [15]. The use of myocutaneous flaps to close the perineal defect after ELAPE adds additional complexity, time, cost and risk of complication both at the perineum and the donor site [18,28]. Closure with mesh be it synthetic or biological also ads cost although may reduce the risk of perineal hernia – a morbid complication requiring complex surgery to repair [29–31]. A recent systematic review demonstrated significant increase in wound complications in their secondary analyses although Musters et al. recent published a meta-analysis specifically examining wound healing and demonstrated no significant difference between standard APR and ELAPE [32]. Increased risk exists whenever additional procedures are performed and this should form part of the decision-making and informed consent process when considering any additional benefit ELAPE will give to the patient. This recent evidence suggests an improvement in patient selection for the use of this technique is warranted. To resolve this discrepancy in outcomes high-quality randomised controlled trials are needed; the most recent systematic review of ELAPE including only one such study. The Dutch BIOPEX-study is the only recruiting trial registered with clinicaltrials.gov (https://clinicaltrials.gov) assessing the role of ELAPE in the management of low rectal cancer [26].

The most up to date data from the UK, recently presented from the Pelican cancer group LOREC database, has revealed around 65% of APRs performed in the UK are Extralevator [34]. We have demonstrated that potentially 8 (11%) of our cohort of unselected low rectal cancer patients could have benefited from this procedure. Furthermore, universal ELAPE resection applied our whole cohort of patients whilst potentially avoiding 8 additional CRM + resections, would have required an additional 62 ELAPE resections. This use of ELAPE would give a number needed to treat of 9 to prevent one CRM + resection. This proportion of tumours approximately corresponds to the reduction of CRM positivity following ELAPE reported in some studies. However, over-zealous use of ELAPE when applied to non-sphincter preserving surgery for low rectal cancer may explain the comparable or poorer CRM positive rates in later studies and this unselected use of ELAPE in the treatment of rectal cancer may explain why the initial oncological benefits are not being realised in larger studies.

Ultimately, patient selection is key in realising the oncological benefit of ELAPE. In our patients, most CRM positive results were in locally advanced (T4 or N1-2) tumours, many sited anteriorly. Identifying this high-risk group pre-operatively following adequate staging with MRI correlated to clinical examination and after discussion

at a colorectal cancer MDT should allow more effective use of ELAPE for the benefit of patients.

5. Conclusion

In low rectal cancer surgery, positive CRM following APR results in significantly increased local recurrence and potentially poorer long-term survival outcomes. ELAPE has been shown to dramatically reduce the rate of CRM positivity, however this improvement is not without potentially increased cost, additional surgery, increased morbidity and poor patient quality of life. In our cohort, we identified a select group of patients with advanced low rectal cancer with positive postero-lateral positive CRM who may have benefited from ELAPE. We would recommend the default use of ELAPE in advanced low rectal cancer after down staging with neo-adjuvant therapy although further studies to refine selection criteria for this procedure are required.

6. Limitations

The major limitations of the current study are that it is a retrospective study of a single high volume tertiary centre in the United Kingdom. Although the general approach of each of the surgeons was similar with regards to workup and technique, individual techniques cannot be entirely homogenous and this is difficult to factor for in our study. Our results will also be applicable to a similarly resourced centre dealing with a similar volume of patients. Additionally we do not currently have long-term follow-up data, which will help determine the overall survival of abdominoperineal resection patients with positive circumferential resection margins.

Ethical approval

Information board review committee has given NOC for this study, that will be uploaded.

Source of funding

Nil.

Author contribution

AH→ Design, data collection, writing.
AT→ Design, Data Analysis, writing.
HC→ Data collection.
CH→ Pathology input.
RD→ Design, Supervision.

Conflicts of interest

Nil.

Research registration number

researchregistry3480.

Guarantor

Anwar Hussain.

References

[1] P.1 How, O. Shihab, P. Tekkis, et al., A systematic review of cancer related patient outcomes after anterior resection and abdominoperineal excision for rectal cancer in the total mesorectal excision era, Surg Oncol 20 (4) (2011) e149–e155, https://doi.org/10.1016/j.suronc.2011.05.001 Epub 2011 Jun 1.

[2] A.1 Huang, H. Zhao, T. Ling, Y. Quan, M. Zheng, B. Feng, Oncological superiority of extralevator abdominoperineal resection over conventional abdominoperineal resection: a meta-analysis, Int. J. Colorectal Dis. 29 (3) (2014) 321–327, https://doi.org/10.1007/s00384-013-1794-6 Epub 2014 Jan 3.

[3] H.C. Yu, H. Peng, X.S. He, R.S. Zhao, Comparison of short- and long-term outcomes after extralevator abdominoperineal excision and standard abdominoperineal excision for rectal cancer: a systematic review and meta-analysis, Int. J. Colorectal Dis. 29 (2) (2014) 183–191, https://doi.org/10.1007/s00384-013-1793-7 Epub 2013 Nov 23.

[4] S. Stelzner, T. Holm, B.J. Moran, et al., Deep pelvic anatomy revisited for a description of crucial steps in extralevator abdominoperineal excision for rectal cancer, Dis. Colon Rectum 54 (8) (2011) 947–957, https://doi.org/10.1097/DCR.0b013e31821c4bac.

[5] J.G. Han, Z.J. Wang, G.H. Wei, Z.G. Gao, Y. Yang, B.C. Zhao, Randomized clinical trial of conventional versus cylindrical abdominoperineal resection for locally advanced lower rectal cancer, Am. J. Surg. 204 (3) (2012 Sep) 274–282, https://doi.org/10.1016/j.amjsurg.2012.05.001.

[6] M. Prytz, E. Angenete, D. Bock, E. Haglind, Extralevator abdominoperineal excision for low rectal cancer-extensive surgery to be used with discretion based on 3-year local recurrence results: a registry-based, observational national cohort study, Ann. Surg. 263 (3) (2016 Mar) 516–521.

[7] M. Prytz, E. Angenete, D. Bock, E. Haglind, Extralevator abdominoperineal excision (ELAPEE) for rectal cancer—short-term results from the Swedish Colorectal Cancer Registry. Selective use of ELAPEE warranted, J Colorectal Dis 29 (2014) 981–987.

[8] Z. Shen, Y. Ye, X. Zhang, et al., Prospective controlled study of the safety and oncological outcomes of ELAPEE procure with definitive anatomic landmarks versus conventional APE for lower rectal cancer, Eur. J. Surg. Oncol. 41 (4) (2015) 472–477, https://doi.org/10.1016/j.ejso.2015.01.017 Epub 2015 Jan 30.

[9] S.K. Perdawood, T. Lund, Extralevator versus standard abdominoperineal excision for rectal cancer, Tech. Coloproctol. 19 (3) (2015) 145–152, https://doi.org/10.1007/s10151-014-1243-8 Epub 2014 Nov 11.

[10] J.G. Han, Z.J. Wang, Q. Qian, et al., A prospective multicenter clinical study of extralevator abdominoperineal resection for locally advanced low rectal cancer, Dis. Colon Rectum 57 (12) (2014) 1333–1340, https://doi.org/10.1097/DCR.0000000000000235.

[11] M. Klein, A. Fischer, J. Rosenberg, I. Gogenur, ExtraLevatory AbdominoPerineal Excision (ELAPEE) does not result in reduced rate of tumor perforation or rate of positive circumferential resection margin: a Nationwide Database Study, Ann Surg May 261 (5) (2015) 933–938, https://doi.org/10.1097/SLA.0000000000000910.

[12] H. Ortiz, M.A. Ciga, P. Armendariz, et al., Spanish Rectal Cancer Project. Multicentre propensity score-matched analysis of conventional versus extended abdominoperineal excision for low rectal cancer, Br. J. Surg. 101 (7) (2014) 874–882, https://doi.org/10.1002/bjs.9522.

[13] G. Palmer, C. Anderin, A. Martling, T. Holm, Local control and survival after extralevator abdominoperineal excision for locally advanced or low rectal cancer, Colorectal Dis. 16 (7) (2014) 527–532, https://doi.org/10.1111/codi.12610.

[14] S.L. Kipling, K. Young, J.D. Foster, et al., Laparoscopic extralevator abdominoperineal excision of the rectum: short-term outcomes of a prospective case series, Tech. Coloproctol. 18 (5) (2014 May) 445–451, https://doi.org/10.1007/s10151-013-1071-2 Epub 2013 Oct 1.

[15] D. Asplund, E. Haglind, E. Angenete, Outcome of extralevator abdominoperineal excision compared with standard surgery: results from a single centre, Colorectal Dis. 14 (10) (2012 Oct) 1191–1196.

[16] N.P. West, C. Anderin, K.J. Smith, T. Holm, P. Quirke, European Extralevator Abdominoperineal Excision Study Group. Multicentre experience with extralevator abdominoperineal excision for low rectal cancer, Br. J. Surg. 97 (4) (2010 Apr) 588–599.

[17] P.G. Vaughan-Shaw, T. Cheung, J.S. Knight, P.H. Nichols, S.A. Pilkington, A.H. Mirnezami, A prospective case-control study of extralevator abdominoperineal excision (ELAPEE) of the rectum versus conventional laparoscopic and open abdominoperineal excision: comparative analysis of short-term outcomes and quality of life, Tech. Coloproctol. 16 (5) (2012 Oct) 355–362, https://doi.org/10.1007/s10151-012-0851-4 Epub 2012 Jul 10.

[18] M. Frasson, B. Flor-Lorente, O. Carreño, Reconstruction techniques after extralevator abdominoperineal rectal excision or pelvic exenteration: meshes, plasties and flaps, Cir. Esp. 92 (1) (2014 Mar) 48–57, https://doi.org/10.1016/S0009-739X(14)70008-9.

[19] A.E. Sayers, R.K. Patel, I.A. Hunter, Perineal hernia formation following extralevator abdominoperineal excision, Colorectal Dis. 17 (4) (2015 Apr) 351–355, https://doi.org/10.1111/codi.12843.

[20] R.A. Agha, M.R. Borrelli, M. Vella-Baldacchino, R. Thavayogan, D.P. Orgill, for the STROCSS Group, The STROCSS statement: strengthening the reporting of cohort studies in surgery, Int. J. Surg. 46 (2017) 198–202.

[21] N. Dabbas, K. Adams, H. Chave, G. Branagan, Current practice in abdominoperineal resection: an email survey of the membership of the Association of Coloproctology, Ann. R. Coll. Surg. Engl. 94 (3) (2012 Apr) 173–176.

[22] Chandler I. Salerno, A. Wotherspoon, K. Thomas, B. Moran, G. Brown, Sites of surgical wasting in the abdominoperineal specimen, Br. J. Surg. 95 (9) (2008 Sep) 1147–1154.

[23] G.M. Bökkerink, E.F. Buijs, W. de Ruijter, et al., Improved quality of care for patients undergoing an abdominoperineal excision for rectal cancer, Eur. J. Surg. Oncol. 41 (2) (2015 Feb) 201–207, https://doi.org/10.1016/j.ejso.2014.11.003 Epub 2014 Nov 29.

[24] A. Krishna, M.J. Rickard, A. Keshava, O.F. Dent, P.H. Chapuis, A comparison of published rates of resection margin involvement and intra-operative perforation between standard and cylindrical APE for low rectal cancer, Colorectal Dis 15 (1) (2013 Jan).

[25] X. Zhou, T. Sun, H. Xie, Y. Zhang, H. Zeng, W. Fu, Extralevator abdominoperineal

excision for low rectal cancer: a systematic review and meta-analysis of the short-term outcome, Colorectal Dis. 17 (2015) 474–481, https://doi.org/10.1111/codi.12921.

[26] G.D. Musters, W.A. Bemelman, R.J. Bosker, et al., Randomized controlled multicentre study comparing biological mesh closure of the pelvic floor with primary perineal wound closure after extralevator abdominoperineal resection for rectal cancer (BIOPEX-study), BMC Surg. 14 (2014 Aug 27) 58, https://doi.org/10.1186/1471-2482-14-58.

[27] R.P. Kennelly, A.C. Rogers, D.C. Winter, Abdominoperineal Excision Study Group. Multicentre study of CRM positivity and outcomes following APE, For Rectal Ca. Br J Surg (1) (2013 Jan) 100.

[28] R. Sinna, M. Alharbi, N. Assaf, et al., Management of the perineal wound after abdominoperineal resection, J. Vis. Surg. 150 (1) (2013 Feb) 9–18, https://doi.org/10.1016/j.jviscsurg.2013.02.001 Epub 2013 Feb 22.

[29] K.K. Jensen, L. Rashid, B. Pilsgaard, P. Møller, P. Wille-Jørgensen, Pelvic floor reconstruction with a biological mesh after extralevator abdominoperineal excision leads to few perineal hernias and acceptable wound complication rates with minor movement limitations: single-centre experience including clinical examination and interview, Colorectal Dis. 16 (3) (2014 Mar) 192–197, https://doi.org/10.1111/codi.12492.

[30] R.L. Harries, A. Luhmann, D.A. Harris, J.A. Shami, B.N. Appleton, Prone extralevator abdominoperineal excision of the rectum with porcine collagen perineal reconstruction (Permacol™): high primary perineal wound healing rates, Int. J. Colorectal Dis. 29 (9) (2014 Sep) 1125–1130, https://doi.org/10.1007/s00384-014-1963-2 Epub 2014 Jul 29.

[31] A.E. Sayers, R.K. Patel, I.A. Hunter, Perineal hernia formation following extralevator abdominoperineal excision, Colorectal Dis. 17 (4) (2015 Apr) 351–355, https://doi.org/10.1111/codi.12843.

[32] G.D. Musters, C.J. Buskens, W.A. Bemelman, P.J. Tanis, Perineal wound healing after abdominoperineal resection for rectal cancer: a systematic review and meta-analysis, Dis. Colon Rectum 57 (9) (2014 Sep) 1129–1139, https://doi.org/10.1097/DCR.0000000000000182.

[33] G. Ramsay, C. Parnaby, C. Mackay, P. Hanlon, S. Ong, M. Loudon, Analysis of outcome using a levator sparing technique of APE of rectum and anus. Cylindrical ELAPEE is not necessary in all patients, Eur. J. Surg. Oncol. (11) (2013 Nov) 39.

[34] H. Jones, S. Crane, B. Moran, C. Cunningham, LOREC, Lorec registry - interim analysis of operative technique and perineal wound healing outcomes after abdomino-perineal excision, Abstract and BJS prize session paper DDF 2015, Colorectal Dis. 19 (2) (2017 Feb) 172–180, https://doi.org/10.1111/codi.13423 Available from: http://www.ddf2015.org.uk/scientific-programe/programmepdfs , Accessed date: 15 July 2015.

[35] M. Aklilu, C. Eng, The current landscape of locally advanced rectal cancer, Nat. Rev. Clin. Oncol. 8 (11) (2011) 649–659.