Surgery Today (2018) 48:978–985
https://doi.org/10.1007/s00595-018-1680-5

ORIGINAL ARTICLE

Extended pelvic resection for rectal and anal canal tumors is a significant risk factor for perineal wound infection: a retrospective cohort study

Ken Imaizumi[1] · Yuji Nishizawa[1] · Koji Ikeda[1] · Yuichiro Tsukada[1] · Takeshi Sasaki[1] · Masaaki Ito[1]

Received: 19 January 2018 / Accepted: 21 May 2018 / Published online: 1 June 2018

Abstract

Purpose Perineal wound infection (PWI) rates are high after abdominoperineal resection (APR) and total pelvic exenteration (TPE). This study identified risk factors for PWI after surgery for anorectal tumors and examined the relationship between the surgical excision volume with the PWI degree.

Methods A retrospective review involving 135 patients who underwent surgical excision of anorectal tumors was performed. Superficial PWI included cellulitis and superficial dehiscence; deep PWI included major dehiscence, perineal abscess, and presacral abscess. The adjacent organ resection type was classified according to the dead space size formed by surgical excision.

Results Of the 135 patients, 119 underwent APR, and 16 underwent TPE. PWI occurred in 75 patients (superficial PWI, 44; deep PWI, 31). Adjacent organ resection was an independent risk factor for PWI. The cases with adjacent organ resection were classified into small-defect APR, large-defect APR, and TPE. Large-defect APR and TPE cases had significantly higher rates of deep PWI than APR cases without adjacent organ resection.

Conclusions Adjacent organ resection involving the removal of one or more organs and that involving wide-range muscle resection are strong risk factors for deep PWI.

Keywords Perineal wound infection · Abdominoperineal resection · Total pelvic exenteration · Adjacent organ resection

Introduction

Abdominoperineal resection (APR) is performed for patients with primary or recurrent low rectal and anal canal tumors. In advanced cases, extensive aggressive surgery, such as total pelvic exenteration (TPE), may be necessary for curative treatment. The perineal wound complication rates associated with APR and TPE may be as high as 60% [1, 2]. These high complication rates are thought to be due to the large dead space in the pelvis following APR and TPE, closure under tension, and closure of a wound in an area with a high bacterial count [3–5]. If primary healing of the perineum does not occur, secondary wound healing may prolong the hospital stay and require surgical reintervention; this often requires intensive wound care for several months and carries a risk of persistent sinusitis development after 1 year [6, 7].

Preoperative radiotherapy and extensive resection are risk factors for complications [8–10]. Extended APR includes extralevator APR, which is widely considered a risk factor for perineal wound complications [10–12], and adjacent organ resection, on which there have been relatively few studies [13]. We were unable to find information in the literature regarding the relationship between the surgical excision volume and the degree of perineal wound infection (PWI). Therefore, the primary aim of this study was to identify risk factors for PWI after surgical excision of the rectum and anal canal for tumor treatment. The secondary aim was to examine the relationship of the surgical excision volume with the degree of PWI.

✉ Yuji Nishizawa
yunishiz@east.ncc.go.jp

✉ Masaaki Ito
maito@east.ncc.go.jp

[1] Department of Colorectal Surgery, National Cancer Center Hospital East, 6-5-1 Kashiwanoha, Kashiwa, Chiba 277-8577, Japan

Methods

Patients

This study included 135 consecutive patients who underwent surgical excision of the rectum and anal canal for tumors at the National Cancer Center Hospital East between April 2008 and June 2016. Patient data were collected retrospectively from clinical records and operative reports. These included the age, sex, body mass index (BMI), smoking status, the presence of diabetes mellitus, diagnosis, preoperative chemotherapy or chemoradiotherapy (CRT), and length of postoperative hospital stay. Surgery information included surgical approach, surgical type, adjacent organ resection, flap reconstruction of the pelvic floor, operative time, and operative blood loss.

The study was approved by the local ethical committee of the National Cancer Center (no. 2016-386). The requirement for informed consent was waived by the ethics review board due to the retrospective nature of the study.

Definition of PWI

PWI was classified as superficial or deep. Superficial PWI included cellulitis and superficial dehiscence, while deep PWI included major dehiscence, perineal abscess, and presacral abscess.

Classification of adjacent organ resection

The type of adjacent organ resection was classified (Fig. 1) according to the size of the dead space after surgical excision. Small-defect APR included abdominoperineal amputation of the rectum with partial resection of seminal vesicles, prostate, vagina, and coccygectomy or sacrectomy. Large-defect APR included abdominoperineal amputation with total prostatectomy, total hysterectomy, and extensive muscle resection (e.g., obturator and gluteus muscles). TPE included abdominoperineal amputation with cystectomy.

Flap reconstruction procedure

A vertical rectus abdominis myocutaneous (VRAM) flap and an ileal flap were used for APR patients combined with total prostatectomy. The VRAM flap was placed behind the cystourethral anastomosis. An ileal flap was created using 5 cm of mucoresected ileum and placed alongside the tissue surrounding the cystourethral anastomosis. A posterior thigh flap was used in cases with a large perineal skin defect for tension-free wound closure.

Statistical analyses

Univariate comparisons of categorical variables were performed using Fisher's exact test. A multivariate logistic regression analysis was performed using a stepwise

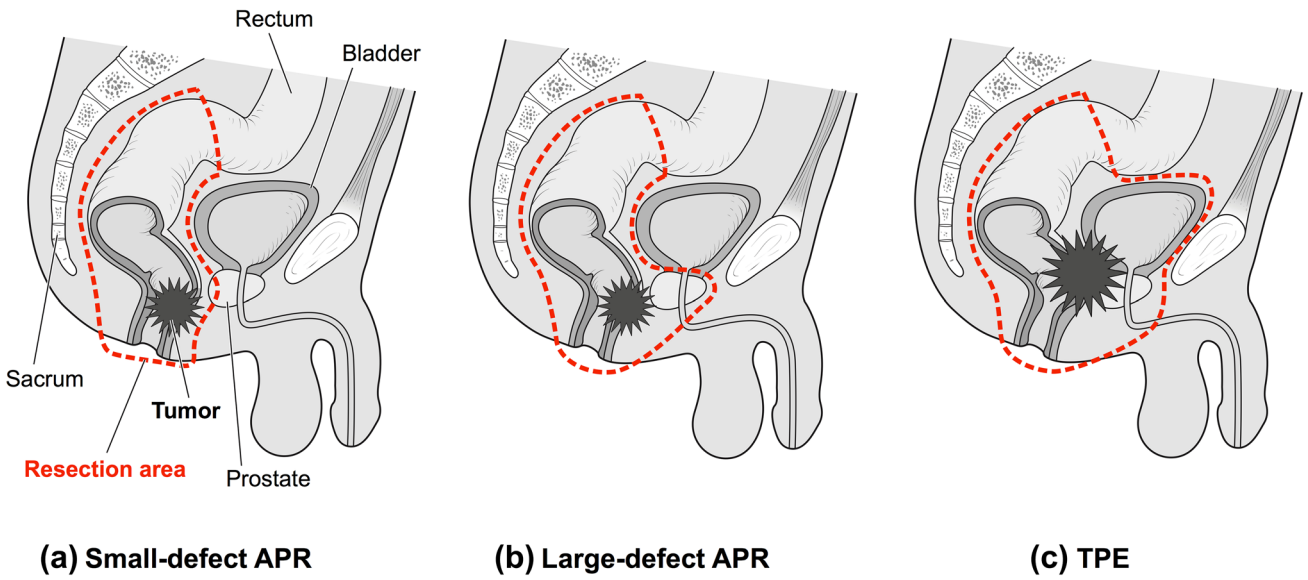

Fig. 1 Classification of adjacent organ resection. **a** Small-defect APR: abdominoperineal amputation with partial resection of seminal vesicles, prostate, vagina, and coccygectomy or sacrectomy. **b** Large-defect APR: abdominoperineal amputation with total prostatectomy, total hysterectomy, and extensive muscle resection (e.g., obturator muscle and gluteus muscle). **c** Total pelvic exenteration (TPE): abdominoperineal amputation with cystectomy

procedure to identify risk factors for PWI involving variables with $p < 0.1$ as covariates in the univariate analysis. Comparisons of categorical variables among three groups were performed using the chi-squared test. Variables that were not normally distributed were assessed using the non-parametric Mann–Whitney *U* test; $p < 0.05$ was considered statistically significant. All analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a modified version of R commander, designed to add statistical functions frequently used in biostatistics [14] and has a graphical user interface (The R Foundation for Statistical Computing, Vienna, Austria).

Results

The patient characteristics are shown in Table 1. Of the total cohort, 119 patients (88%) underwent APR and 16 (12%) underwent TPE. The median age was 63 years (range, 31–82); 95 patients (70%) were male and 40 (30%) were female. The median operative time was 418 min (range 190–733). The median operative blood loss was 690 mL (range 12–10,657). Adjacent organ resection, including TPE, was performed in 54 patients (40%). Flap reconstruction was performed in 10 APR patients (7.5%). PWI occurred in 75 (56%) patients, including superficial PWI in 44 (33%) and deep PWI in 31 (23%).

A univariate analysis showed that male sex ($p = 0.059$), preoperative CRT ($p = 0.055$), adjacent organ resection ($p = 0.014$), flap reconstruction ($p = 0.042$), and operative time > 420 min ($p = 0.057$) were potential risk factors for PWI. These factors were included in the multivariate analysis, in which adjacent organ resection was identified as an independent significant risk factor for PWI [odds ratio (OR), 2.620; 95% confidence interval (CI), 1.150–5.940; $p = 0.022$] (Table 2).

Adjacent organ resection was classified as small-defect APR in 22 (16%) patients, large-defect APR in 16 patients, and TPE in 16 (12%) patients. Details of the excised organs are shown in Table 3. Simple APR (without adjacent organ resection) was performed in 81 (60%) patients. There were no marked differences in demographics between simple APR and small-defect APR cases ($p = 0.878$), or between large-defect APR and TPE cases ($p = 0.662$). However, the rate of PWI, particularly deep PWI, was significantly higher in patients with large-defect APR and TPE than in patients with simple APR ($p = 0.002$, $p = 0.028$) and in patients with large-defect APR than in those with small-defect APR ($p = 0.018$). There was no significant difference in the rate of PWI between small-defect APR and TPE ($p = 0.094$) (Fig. 2).

Flap reconstruction was performed in two cases using a VRAM flap, in four cases using a posterior thigh flap, and in four cases using an ileal flap (Table 1). The characteristics of APR patients with and without flap reconstruction are presented in Table 4. All patients who underwent flap reconstruction were male, and almost all had large-defect APR. Patients with APR and flap reconstruction had a significantly longer operative time (median, 382 vs. 609 min; $p < 0.001$) and greater operative blood loss (median, 450 vs. 1540 ml; $p = 0.004$) than those treated without flap reconstruction. Nine (90%) patients who underwent flap reconstruction had PWI, and 5 (50%) had deep PWI.

Patients with PWI had longer postoperative hospital stays than those without PWI. The median postoperative stay was 15 (range 9–44), 18 (range 9–193), and 23 (range 12–128) days in patients with no PWI, superficial PWI, and deep

Table 1 Patient characteristics and operative data

Characteristics ($n = 135$)	
Age (years)[a]	63 (31–87)
Sex	
Male	95 (70%)
Female	40 (30%)
Body mass index (kg/m^2)[a]	21.7 (15.8–37.2)
Smoking	81 (60%)
Diabetes mellitus	15 (11%)
Diagnosis	
Rectal and anal canal cancer	113 (84%)
Recurrence	18 (13%)
Gastrointestinal stromal tumor	2 (1.5%)
Melanoma	2 (1.5%)
Preoperative chemotherapy	35 (26%)
Bevacizumab	11 (8%)
Preoperative chemoradiotherapy	21 (16%)
Operative data	
Surgical approach	
Open	57 (42%)
Laparoscopic	78 (58%)
Surgical type	
Abdominoperineal resection	119 (88%)
TPE	16 (12%)
Adjacent organ resection (including TPE)	54 (40%)
Flap reconstruction	
Vertical rectus abdominis myocutaneous flap	2 (1.5%)
Anterolateral thigh flap	4 (3%)
Ileal flap	4 (3%)
Operative time (min)[a]	418 (190–733)
Operative blood loss (ml)[a]	690 (12–10657)
Perineal wound infection	
No	60 (44%)
Superficial	44 (33%)
Deep	31 (23%)

TPE total pelvic exenteration

[a]Median (range)

Table 2 Risk factors for PWI

Risk factors	No PWI	PWI	Fisher's exact test	Multivariable logistic regression analysis	
	$n=60$	$n=75$	P	P	OR (95% CI)
Age ≥ 70 years					
Yes	21 (45%)	26 (55%)	1.000	–	
No	39 (44%)	49 (56%)			
Sex					
Male	37 (39%)	58 (61%)	0.059	0.388	–
Female	23 (58%)	17 (43%)			
Body mass index ≥ 25 kg/m^2					
Yes	12 (50%)	12 (50%)	0.652	–	
No	48 (43%)	63 (57%)			
Smoking					
Yes	33 (41%)	48 (59%)	0.584	–	
No	27 (50%)	27 (50%)			
Diabetes mellitus					
Yes	9 (60%)	6 (40%)	0.271	–	
No	51 (43%)	69 (58%)			
Preoperative chemotherapy					
Yes	15 (43%)	20 (57%)	0.846	–	
No	45 (45%)	55 (55%)			
Bevacizumab					
Yes	4 (36%)	7 (64%)	0.754	–	
No	56 (45%)	68 (55%)			
Preoperative chemoradiotherapy					
Yes	5 (24%)	16 (76%)	0.055	0.655	–
No	55 (48%)	59 (52%)			
Laparoscopic surgery					
Yes	26 (46%)	31 (54%)	0.862	–	
No	34 (44%)	44 (56%)			
Adjacent organs resection					
Yes	17 (32%)	37 (69%)	0.014	0.022	2.620 (1.150–5.940)
No	43 (53%)	38 (47%)			
Flap reconstruction					
Yes	1 (10%)	9 (90%)	0.042	0.179	–
No	59 (47%)	66 (53%)			
Operative time ≥ 420 min					
Yes	24 (36%)	43 (64%)	0.057	0.488	–
No	36 (53%)	32 (47%)			
Operative blood loss ≥ 700 ml					
Yes	24 (37%)	41 (63%)	0.119	–	
No	36 (51%)	34 (49%)			

CI confidence interval, *OR* odds ratio, *PWI* perineal wound infection

PWI, respectively (Fig. 3). Significantly longer postoperative hospital stays were required for patients with PWI than for those without PWI, as well as for patients with superficial PWI than for those without PWI ($p=0.035$), and for patients with deep PWI than for those without PWI ($p<0.001$). However, there was no significant difference in the length of stay between patients with superficial and deep PWI ($p=0.096$).

Discussion

Perineal wounds are associated with a high risk of surgical site infection (SSI). The large amount of dead space left in the pelvis after resection of the rectum and anal canal with adjacent organ resection increases the chances of fluid accumulation in an area that has a high bacterial count,

Table 3 Details of excised adjacent organs and structures

Type of adjacent organ resection ($n=135$)	n (%)
Simple APR	81 (60%)
Small-defect APR[a]	22 (16%)
Partial resection of prostate (and seminal vesicle)	7 (5%)
Partial resection of vagina	10 (7%)
Coccygectomy/sacrectomy	8 (6%)
Large-defect APR[a]	16 (12%)
Total prostatectomy	9 (7%)
Vulvectomy and total hysterectomy	6 (4%)
Extensive resection of muscle	4 (3%)
Total pelvic exenteration	16 (12%)

APR abdominoperineal resection

[a]There is some duplication

which creates an ideal environment for wound infections [15]. A systematic review indicated that preoperative radiotherapy increases the rate of perineal wound complications after APR [9]. Several reports have shown that the use of extended APR to obtain a clear circumferential resection margin resulted in a large defect and primary closure under tension [10, 12, 16]. However, there has been only one report on adjacent organ resection during anorectal surgery [13]. There have been no detailed reports on the relationship between the degree of pelvic dead space and PWI.

In the current study, adjacent organ resection was found to be a significant risk factor for PWI. In particular, large-defect APR and TPE were found to present greater risks for deep PWI than simple APR, whereas small-defect APR and simple APR carried equivalent risks. This indicates that partial resection of other organs does not increase the risk of PWI, and the removal of one or more organs and wide-range muscle resection can carry a risk for deep PWI. The dead space becomes larger as the volume of surgical resection increases, and there is a corresponding increase in the deep PWI rate. This suggests that preventive measures are required in such high-risk cases.

Various methods of pelvic reconstruction after extended APR have been suggested. Reconstruction involving autologous tissue as an omental pedicle flap (omentoplasty) or myocutaneous flap can be performed for the closure of perineal wounds, resulting in a lower rate of perineal wound complications than with primary closure used for standard APR [17–20]. However, the effectiveness of omentoplasty was not shown in a recent large cohort study [21]. In some cases, this procedure may not reach the pelvic floor. The usefulness of a myocutaneous flap was indicated in a randomized controlled study [22], but this flap has the disadvantages of a longer operative time and substantial blood loss [22]. Therefore, this procedure should not be performed for all cases. We used this flap procedure to protect the anastomotic site in cases of APR and intersphincteric resection involving organ reconstruction [23]. The present findings suggest there is still room for improvement in the prevention of PWI. Therefore, in APR with a large amount of dead space as well as in TPE, both of which were found to be risk factors for deep PWI in the current study, pelvic reconstruction should be considered. Furthermore, negative pressure wound therapy improves the blood supply and decreases the perineal SSI rate after APR [16, 24, 25]. These findings were based on small retrospective studies, but we believe that this therapy may be effective for closing the perineal wound after APR and TPE when there is a high risk of PWI.

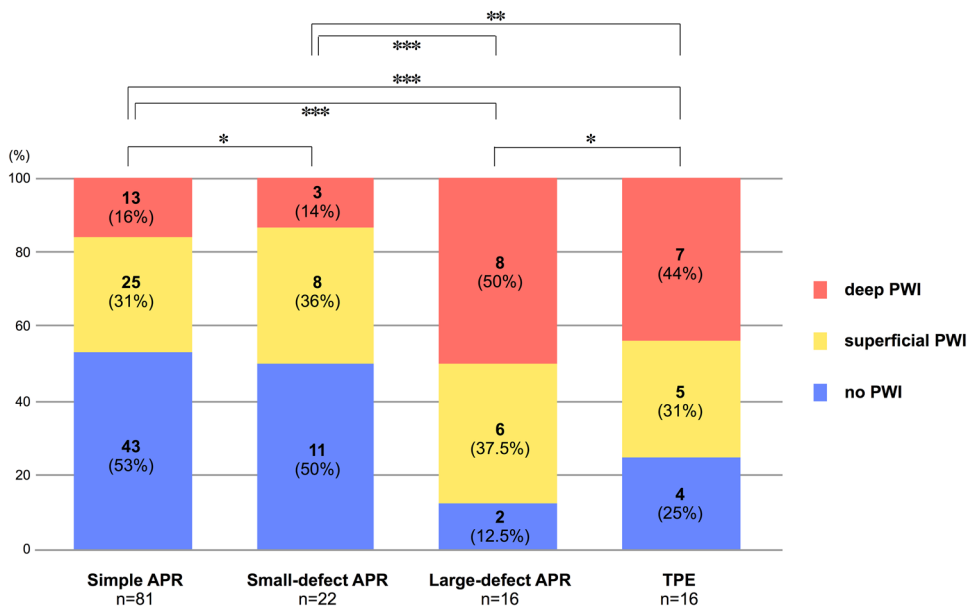

Fig. 2 Relationship between adjacent organ resection and perineal wound infection. *$p \geq 0.1$, **$p \geq 0.05$ to $p < 0.1$, and ***$p < 0.05$ according to Chi-square test

Table 4 A comparison of APR patients treated with and without flap reconstruction

Characteristics ($n=135$)	APR without FR ($n=109$)	APR with FR ($n=10$)	P
Age (years)[a]	63 (31–87)	66.5 (38–84)	0.856
Sex			
Male/female	69/40	10/0	0.016
Body mass index (kg/m^2)[a]	21.7 (15.8–37.2)	21.9 (18.8–25.2)	0.912
Smoking	62 (57%)	6 (60%)	1.000
Diabetes mellitus	13 (12%)	1 (10%)	1.000
Diagnosis			
Rectal and anal canal cancer	94 (84%)	10 (100%)	0.884
Recurrence	11 (13%)	0 (0%)	
GIST/melanoma	4 (3%)	0 (0%)	
Preoperative chemotherapy	28 (26%)	3 (30%)	0.719
Bevacizumab	5 (5%)	2 (20%)	0.107
Preoperative chemoradiotherapy	11 (10%)	3 (30%)	0.095
Surgical approach			
Open	59 (54%)	5 (50%)	1.000
Laparoscopic	50 (46%)	5 (50%)	
Adjacent organs resection			
No	80 (73%)	1 (10%)	<0.001
Small defect	21 (19%)	1 (10%)	
Large defect	8 (7%)	8 (80%)	
Operative time (min)[a]	382 (190–733)	609 (493–728)	<0.001
Operative blood loss (ml)[a]	450 (12–10657)	1540 (272–9249)	0.004
Perineal wound infection			
No	55 (51%)	1 (10%)	0.013
Superficial	35 (32%)	4 (40%)	
Deep	19 (17%)	5 (50%)	

APR abdominoperineal resection, *FR* flap reconstruction, *GIST* gastrointestinal stromal tumor
[a]Median (range)

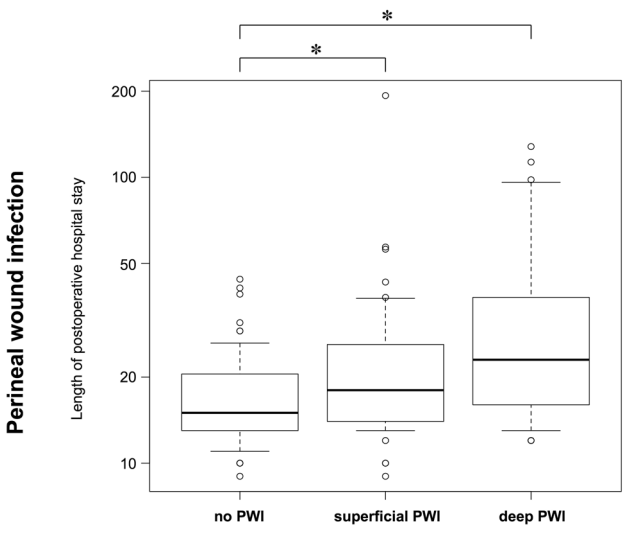

Fig. 3 Relationship between the perineal wound infection degree and the length of the postoperative hospital stay. *$p<0.05$ by Mann–Whitney U test

The deep PWI rate of approximately 30% after large-defect APR and TPE was higher than that after simple APR. Furthermore, PWI prolonged the postoperative hospital stay. According to a study on wound dehiscence in APR patients, the mean healing time was 117 days, with a range of up to 1,096 days [26]. Delayed wound healing of up to one year is common, and some patients have to live with chronic perineal wounds [27]. Selective pelvic reconstruction for high-risk cases is likely to reduce medical costs and improve the quality of life. Therefore, prospective studies on the effects of flap reconstruction and negative pressure wound therapy are required in future.

Several limitations associated with the present study warrant mention. First, this was a retrospective review and single-center study. Second, although we used a definition of PWI similar to that used in other studies [9], there is no standard definition of PWI. This has resulted in a wide variation in the reported rate of PWI among different studies. Third, the number of preoperative CRT cases was small in this study. Therefore, preoperative CRT was not a significant risk factor for PWI. However, many reports have

shown an increased rate of perineal wound complications in APR after CRT [9, 28]. Therefore, such complications in patients treated with preoperative CRT, especially when surgery results in a large amount of dead space, should be considered. Fourth, there was no significant difference in the length of the postoperative hospital stay between patients with superficial PWI and those with deep PWI. However, the number of cases was small, so this result requires validation in a future prospective study.

Conclusion

PWI is a frequent and severe complication after amputation of the rectum and anal canal because of tumors and has major negative effects on medical costs and the patients' quality of life. Our results showed that adjacent organ resection involving the removal of one or more organs and wide-range muscle resection are strong risk factors for deep PWI.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

References

1. de Bruin AF, Gosselink MP, Wijffels NA, Coene PP, van der Harst E. Local gentamicin reduces perineal wound infection after radiotherapy and abdominoperineal resection. Tech Coloproctol. 2008;12:303–7.
2. Kuhrt MP, Chokshi RJ, Arrese D, Martin EW Jr. Retrospective review of pelvic malignancies undergoing total pelvic exenteration. World J Surg Oncol. 2012;10:110.
3. Shukla HS, Tewari M. An evolution of clinical application of inferior pedicle based rectus abdominis myocutaneous flap for repair of perineal defects after radical surgery for cancer. J Surg Oncol. 2010;102:287–94.
4. Holm T, Ljung A, Häggmark T, Jurell G, Lagergren J. Extended abdominoperineal resection with gluteus maximus flap reconstruction of the pelvic floor for rectal cancer. Br J Surg. 2007;94:232–8.
5. Althumairi AA, Canner JK, Gearhart SL, Safar B, Sacks J, Efron JE. Predictors of perineal wound complications and prolonged time to perineal wound healing after abdominoperineal resection. World J Surg. 2016;40:1755–62.
6. Nissan A, Guillem JG, Paty PB, Douglas Wong W, Minsky B, Saltz L, Cohen AM. Abdominoperineal resection for rectal cancer at a specialty center. Dis Colon Rectum. 2001;44:27–35.
7. El-Gazzaz G, Kiran RP, Lavery I. Wound complications in rectal cancer patients undergoing primary closure of the perineal wound after abdominoperineal resection. Dis Colon Rectum. 2009;52:1962–6.
8. Bullard KM, Trudel JL, Baxter NN, Rothenberger DA. Primary perineal wound closure after preoperative radiotherapy and abdominoperineal resection has a high incidence of wound failure. Dis Colon Rectum. 2005;48:438–43.
9. Musters GD, Buskens CJ, Bemelman WA, Tanis PJ. Perineal wound healing after abdominoperineal resection for rectal cancer. Dis Colon Rectum. 2014;57:1129–39.
10. West NP, Anderin C, Smith KJ, Holm T, Quirke P. Multicentre experience with extralevator abdominoperineal excision for low rectal cancer. Br J Surg. 2010;97:588–99.
11. Yu HC, Peng H, He XS, Zhao RS. 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. 2014;29:183–91.
12. West NP, Finan PJ, Anderin C, Lindholm J, Holm T, Quirke P. Evidence of the oncologic superiority of cylindrical abdominoperineal excision for low rectal cancer. J Clin Oncol. 2008;26:3517–22.
13. Mesquita Neto JW, Machado DB, Macedo DJ, Cordeiro DF, Brito EV, Costa ML. Extended pelvic resections for the treatment of locally advanced and recurrent anal canal and colorectal cancer: technical aspects and morbimortality predictors after 24 consecutive cases. Rev Col Bras Cir. 2016;43:93–101.
14. Kanda Y. Investigation of the freely available easy-to-use software "EZR" for medical statistics. Bone Marrow Transplant. 2013;48:452–8.
15. Combs PD, Sousa JD, Louie O, Said HK, Neligan PC, Mathes DW. Comparison of vertical and oblique rectus abdominis myocutaneous flaps for pelvic, perineal, and groin reconstruction. Plastic Reconst Surg. 2014;134:315–23.
16. Sumrien H, Newman P, Burt C, McCarthy K, Dixon A, Pullyblank A, et al. The use of a negative pressure wound management system in perineal wound closure after extralevator abdominoperineal excision (ELAPE) for low rectal cancer. Tech Coloproctol. 2016;20:627–31.
17. Hay JM, Fingerhut A, Paquet JC, Flamant Y. Management of the pelvic space with or without omentoplasty after abdominoperineal resection for carcinoma of the rectum: a prospective multicenter study. The French Association for Surgical Research. Eur J Surg. 1997; 163:199–206.
18. Hultman CS, Sherrill MA, Halvorson EG, Lee CN, Boggess JF, Meyers MO, et al. Utility of the omentum in pelvic floor reconstruction following resection of anorectal malignancy. Ann Plast Surg. 2010;64:559–62.
19. Butler CE, Gündeslioglu AO, Rodriguez-Bigas MA. Outcomes of immediate vertical rectus abdominis myocutaneous flap reconstruction for irradiated abdominoperineal resection defects. J Am Coll Surg. 2008;206:694–703.
20. Chan S, Miller M, Ng R, Ross D, Roblin P, Carapeti E, et al. Use of myocutaneous flaps for perineal closure following abdominoperineal excision of the rectum for adenocarcinoma. Colorectal Dis. 2010;12:555–60.
21. Blok RD, Musters GD, Borstlap WAA, Buskens CJ, Bemelman WA, Tanis PJ, et al. Snapshot study on the value of omentoplasty in abdominoperineal resection with primary perineal closure for rectal cancer. Ann Surg Oncol. 2018;25:729–36.
22. Touny A, Othman H, Maamoon S, Ramzy S, Elmarakby H. Perineal reconstruction using pedicled vertical rectus abdominis myocutaneous flap (VRAM). J Surg Oncol. 2014;110:752–7.
23. Noguchi K, Nishizawa Y, Komai Y, Sakai Y, Kobayashi A, Ito M, et al. Efficacy of an additional flap operation in bladder-preserving surgery with radical prostatectomy and cystourethral anastomosis for rectal cancer involving the prostate. Surg Today. 2017;47:1119–28.
24. Chadi SA, Kidane B, Britto K, Brackstone M, Ott MC. Incisional negative pressure wound therapy decreases the frequency of postoperative perineal surgical site infections: a cohort study. Dis Colon Rectum. 2014;57:999–1006.
25. Wiegering A, Dietz UA, Corteville C, Plaßmeier L, Jurowich C, Germer C-T, et al. Impact of incisional negative pressure wound

therapy on perineal wound healing after abdominoperineal rectum extirpation. Int J Colorectal Dis. 2017;32:291–3.
26. Hawkins AT, Berger DL, Shellito PC, Sylla P, Bordeianou L. Wound dehiscence after abdominoperineal resection for low rectal cancer is associated with decreased survival. Dis Colon Rectum. 2014;57:143–50.
27. Artioukh DY, Smith RA, Gokul K. Risk factors for impaired healing of the perineal wound after abdominoperineal resection of rectum for carcinoma. Colorect Dis. 2007;9:362–7.
28. Papaconstantinou HT, Bullard KM, Rothenberger DA, Madoff RD. Salvage abdominoperineal resection after failed Nigro protocol: modest success, major morbidity. Colorect Dis. 2006;8:124–9.