

Pelvic/Perineal Reconstruction: Time to Consider the Anterolateral Thigh Flap as a First-line Option?

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Background: Abdominoperineal resection (APR) and pelvic exenteration continue to be common procedures for the treatment of colorectal malignancy. The workhorse flap for reconstruction in these instances has been the vertical rectus abdominis myocutaneous flap. The associated donor site morbidity, however, cannot be ignored. Here, we provide a review of the literature and present the senior author's (A.M.) experience using the pedicled anterolateral thigh (ALT) flap for reconstruction of soft tissue defects following APR and pelvic exenteration.

Methods: Patients who underwent pelvic/perineal reconstruction with pedicled ALT flaps between 2017 and 2019 were included in the study. Parameters of interest included age, gender, body mass index, comorbidities, history of radiation, extent of ablative surgery, and postoperative complication rate.

Results: A total of 23 patients (16 men and 7 women) with a median age and body mass index of 66 years (inter-quartile range [IQR]: 49–71 years) and 24.9 kg/m² (IQR: 24.2–26.7 kg/m²) were included in the study, respectively. Thirteen (56.5%) patients presented with rectal cancer, 5 (21.7%) with anal squamous cell carcinoma (SCC), 4 (17.4%) with Crohn's disease, and 1 (4.3%) with Paget's disease. Nineteen patients (82.6%) received neoadjuvant radiation. Nine (39.1%) patients experienced 11 complications (2 major and 9 minor). The most common complication was partial perineal wound dehiscence (N = 6 [26.1%]). Stable soft tissue coverage was achieved in all but one patient.

Conclusions: The ALT flap allows for stable soft tissue coverage following APR and pelvic exenteration without being associated with abdominal donor site morbidity. Consideration to its use as a first-line reconstructive option should be given in pelvic/perineal reconstruction. (*Plast Reconstr Surg Glob Open* 2020;8:e2733; doi: 10.1097/GOX.0000000000002733; Published online 24 April 2020.)

INTRODUCTION

Abdominoperineal resection (APR) and pelvic exenteration continue to be common procedures for the treatment of colorectal malignancy.^{1,2} These procedures result in defects that are characterized by a noncollapsible pelvic dead space, skin defect, as well as occasionally a vaginal defect. Primary closure of these defects is associated with a high rate of wound complications.^{1,3} Importantly, a 10-fold increase in wound complication rate has been reported

in the setting of neoadjuvant radiation.⁴ This is particularly relevant as the majority of patients with colorectal malignancy scheduled to undergo APR or pelvic exenteration undergo neoadjuvant radiation. The characteristics of the resultant pelvic/perineal defect determine the goals of reconstruction, namely (1) stable skin and soft tissue coverage, (2) obliteration of pelvic dead space with well-vascularized nonirradiated tissue, and (3) anatomic reconstruction of the perineal structures.

There is an extensive body of literature supporting flap-based reconstruction of perineal and pelvic defects.^{1,2,5–24} Two recent meta-analyses reported on superior outcomes following flap-based reconstruction (versus primary closure) regarding total perineal wound complications and infections.^{1,25}

The workhorse flap for pelvic/perineal reconstruction following APR or pelvic exenteration has been the vertical rectus abdominis myocutaneous (VRAM) flap. Advantages include reliable anatomy, ease of flap harvest, robust perfusion, and adequate bulk to obliterate pelvic dead space.^{18,26} However, its use mandates sacrifice of the rectus abdominis

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muscle and, thus, is associated with a nonnegligible degree of donor site morbidity, such as abdominal bulge and hernia formation.²⁷ Although a variety of technical modifications (eg, fascia-sparing flap harvest) have been introduced to minimize donor site morbidity, iatrogenic insult to the abdominal wall remains a concern.²⁸ In fact, depending on technique, a 1.5%–26% rate of bulge and hernia formation has been reported following VRAM flap harvest.^{28,29}

Furthermore, the use of VRAM flaps is problematic in cases of pelvic exenteration due to the need for a colostomy and urostomy. Although pelvic exenteration does not preclude the ability to use VRAM flaps for reconstruction, harvest thereof can be associated with complications at the respective ostomy site, including formation of parastomal hernias.^{28,29} Additionally, rectus abdominis muscle harvest can complicate future ostomy revision or repositioning.³⁰ Finally, in light of an increasing number of laparoscopy- and robot-assisted resections being performed, the morbidity associated with the VRAM flap appears to negate the benefits of the minimally invasive approach used by our colorectal surgery colleagues.³¹

A commonly used alternative to the VRAM flap is the gracilis flap. It can be used as either a muscle-only flap or a myocutaneous flap. Proponents have commented on its ease of harvest and complete avoidance of abdominal wall morbidity.^{32,33} Drawbacks, however, include limited muscle bulk and, at times, unreliable skin perfusion.¹⁷

The anterolateral thigh (ALT) flap has only recently been considered a suitable option for pelvic/perineal reconstruction after APR or pelvic exenteration.³⁰ It combines the advantages of the VRAM and gracilis flap, notably, large soft tissue bulk, reliable anatomy, and robust perfusion to a large skin segment, while sparing the abdomen, thus eliminating the risk of hernia or abdominal bulge formation.

Here, we provide a review of the literature and present the senior author's (A.M.) experience using the pedicled ALT flap for reconstruction following APR and pelvic exenteration.

METHODS

Institutional review board approval was obtained before conducting the study. Data were prospectively collected on patients who underwent APR (with or without vaginal resection) or pelvic exenteration between 2017 and 2019. Only patients who underwent soft tissue reconstruction with pedicled ALT flaps by the senior author (A.M.) were included in the study. We included patients with rectal cancer, anal squamous cell carcinoma, inflammatory bowel disease, and Paget's disease.

Patient age, gender, body mass index (BMI), comorbidities, history of radiation, extent of ablative surgery, and postoperative complications were recorded. Complications were categorized as either minor (ie, managed in the outpatient setting) or major (ie, requiring admission and/or return to the operating room).

Differences in age, gender, BMI, comorbidities, history of radiation, and extent of ablative surgery were compared between patients with and without wound complications. Continuous variables were converted to categorical

variables: specifically, age was categorized as younger than or older than 65 years and BMI was categorized as <25 or >25 kg/m². Categorical variables were expressed as proportions and analyzed by Fisher's exact test in Prism 8 (GraphPad Software, Inc; San Diego, CA).

Surgical Technique

Following completion of the ablative component of the procedure, the defect was analyzed. Specifically, the extent of skin defect and mucosal (vaginal) defect was determined as this would impact the size of the ALT flap skin paddle (Figs. 1, 2). The surgical site was repped and redraped. The ALT flap was designed along the axis between the anterior superior iliac spine and the superolateral border of the patella. We did not routinely determine the location of perforators as we typically raised the ALT flap as a myocutaneous flap with the superficial leaflet of the vastus lateralis muscle being used for pelvic dead space obliteration. The skin incision was made along the anterior border of the flap. Dissection was carried out through the subcutaneous tissue and fascia lata until the rectus femoris muscle was visualized. Next, the septum between the rectus femoris and vastus lateralis muscle was entered with dissection proceeding proximally until the flap pedicle, that is, descending branch of the lateral femoral circumflex artery and venae comitantes, would come into view. Retrograde pedicle dissection was then performed. Of note, the vascular branch to the rectus femoris muscle was routinely clipped and divided with pedicle

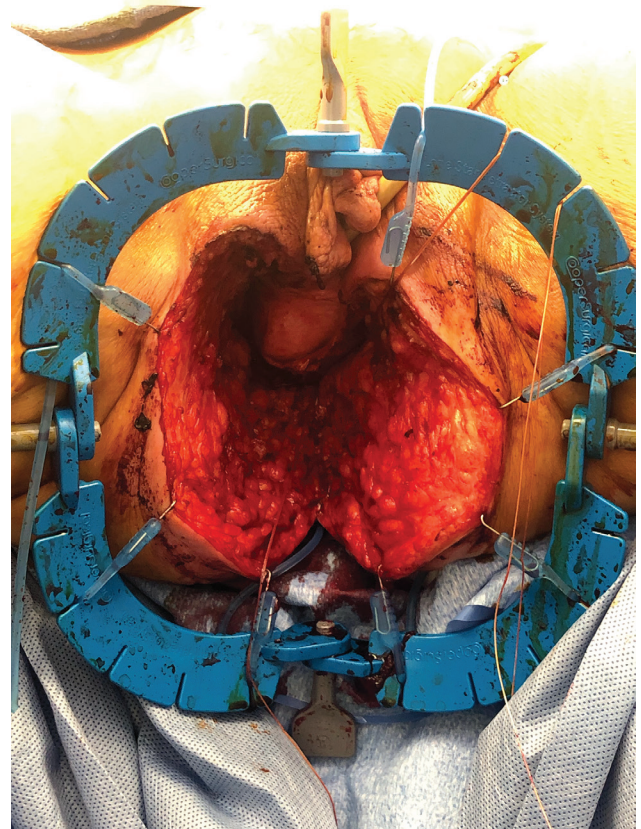


Fig. 1. Perineal and type IB vaginal defect.

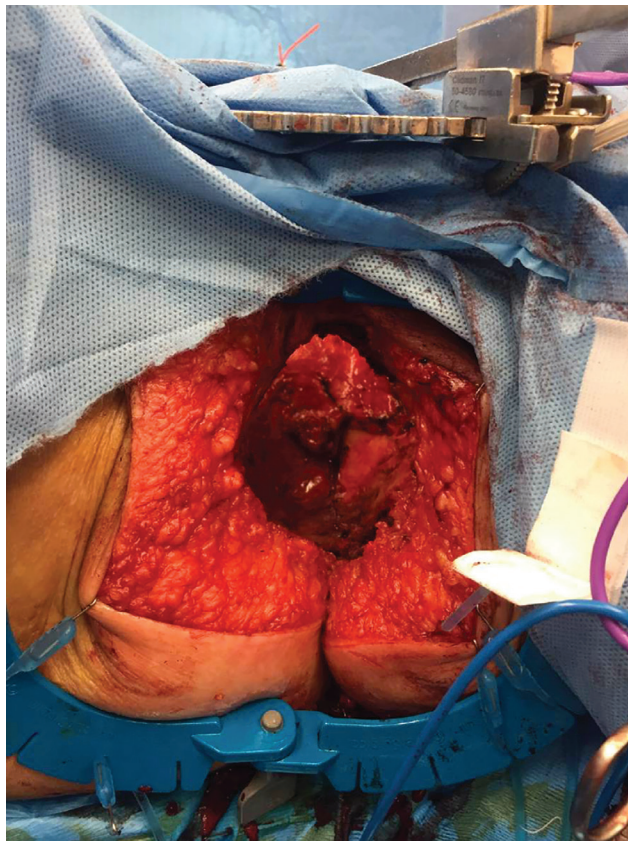


Fig. 2. Large soft tissue defect following pelvic exenteration.

dissection proceeding proximally until flap transfer was possible without undue tension on the pedicle. A tunnel was then created under the rectus femoris and sartorius muscles toward the medial thigh (Fig. 3). Medial to the sartorius muscle, the plane of dissection transitioned to the subcutaneous plane. Occasionally, a short counterincision was made in the medial thigh to aid in safe dissection of the tunnel. Particular attention was paid toward



Fig. 3. A tunnel is created under the rectus femoris and sartorius muscles. Medial to the sartorius muscle, the plane of dissection transitions to the subcutaneous plane.

ensuring that an adequately wide tunnel was created so as to not compress the flap pedicle. Finally, the subcutaneous tunnel was connected to the perineal defect.

Next, the superficial partition of the vastus lateralis muscle was elevated in a medial-to-lateral direction. The amount of muscle raised with the flap was determined by the degree of pelvic dead space. After an adequate amount of muscle was included with the flap, the lateral skin incision was made and the flap was islandized on its vascular pedicle. The flap was then tunneled and inset into the defect. Particular attention was paid to ensuring that the vascular pedicle was not under any degree of tension during inset (Fig. 4). Depending on the extent of the defect, the colorectal surgeons would place sutures at desired locations within the pelvis. These sutures would then be used to parachute the ALT flap into the defect, thus ensuring flap transfer into the desired location with successful dead space obliteration. Primary donor site closure was achieved in all patients in this study.

Postoperatively, patients were allowed to ambulate on postoperative day 1. Sitting restrictions were implemented for 2 weeks. Figures 5 and 6 demonstrate pre- and postoperative images of representative cases.

RESULTS

A total of 23 patients (16 men and 7 women) with a median age of 66 years (IQR: 49–71 years) were included in

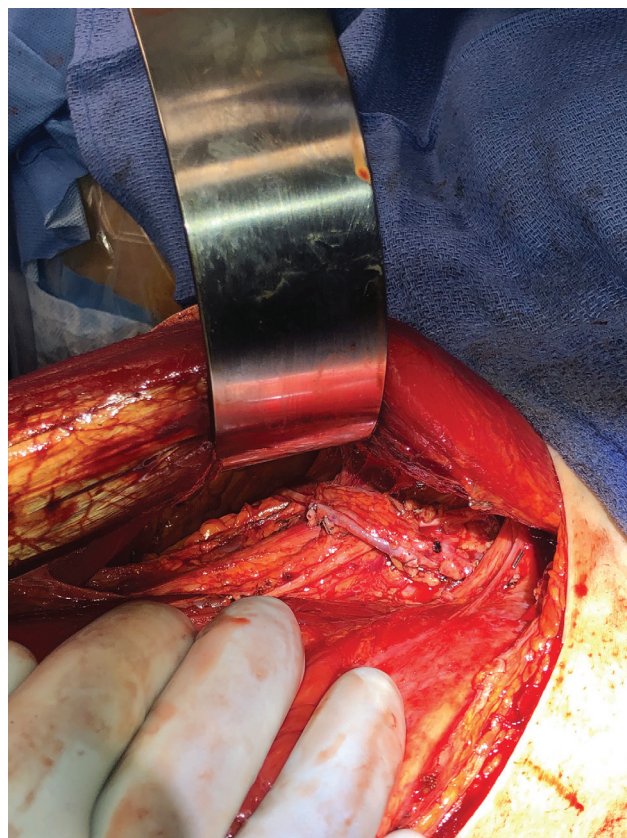


Fig. 4. Tension-free position of the vascular pedicle following flap transfer.



Fig. 5. Pre- and postoperative image of a perineal and type IB vaginal defect followed by perineal and vaginal reconstruction with a pedicled ALT flap.

the study. Median BMI was 24.9 kg/m² (IQR: 24.2–26.7 kg/m²). Comorbidities included diabetes (N = 7; 30.4%), hypertension (N = 9; 39.1%), coronary artery disease (N = 4; 17.4%), chronic obstructive pulmonary disease (N = 2; 17.4%), and chronic liver disease (N = 1; 4.3%). Thirteen (56.5%) patients presented with rectal cancer, 5 (21.7%) with anal SCC, 4 (17.4%) with Crohn’s disease, and 1 (4.3%) with Paget’s disease. Nineteen (82.6%) patients received neoadjuvant radiation (Tables 1, 2).

There were no operative or 30-day mortalities. In our series, 9 (39.1%) patients experienced 11 complications (2 major and 9 minor). Two (8.7%) patients experienced

major complications, including sacral osteomyelitis, donor site seroma, and perineal wound dehiscence from a urinary leak following pelvic exenteration. The most common complication was partial perineal wound dehiscence (N = 6 [26.1%]). On most recent follow-ups, all dehiscenced wounds were healed, excluding the patient with sacral osteomyelitis. Two patients experienced donor site complications, including leg weakness (N = 2 [8.7%] and donor site seroma (N = 1 [4.3%]). Notably, both patients who initially experienced leg weakness had an unremarkable functional recovery. One (4.3%) patient developed deep vein thrombosis (DVT) postoperatively (Table 3).



Fig. 6. Pre- and postoperative image of a perineal defect following pelvic exenteration and soft tissue reconstruction with a pedicled ALT flap (without reconstruction of a neovagina).

Table 1. Patient Demographics

Patient	Age (y)	Gender	BMI (kg/m ²)	Diagnosis	Comorbidities	Radiation Therapy	Oncologic Procedure
1	66	M	24.3	Rectal cancer	DM	Yes	APR
2	42	M	24.9	Crohn's disease		No	APR
3	58	F	26.3	Recurrent anal cancer		Yes	APR + posterior vaginectomy
4	82	M	22.3	Rectal cancer	COPD	Yes	APR
5	84	M	24.7	Rectal cancer	HTN, CAD, DM	Yes	APR
6	66	M	24.4	Rectal cancer		Yes	APR
7	48	M	28.3	Recurrent rectal cancer	HTN, HLP	Yes	APR
8	67	M	23.1	Recurrent rectal cancer		Yes	APR
9	69	F	25.4	Rectal cancer	HTN, HLP, DM	Yes	APR + posterior vaginectomy
10	67	M	29.1	Rectal cancer	DM	Yes	APR
11	72	M	33.7	Rectal cancer	HTN	Yes	Pelvic exenteration
12	60	F	24.1	Recurrent anal cancer		Yes	Pelvic exenteration
13	23	M	18.9	Crohn's disease		No	APR
14	58	F	38.3	Recurrent anal cancer	HTN	Yes	Pelvic exenteration
15	73	M	24.7	Rectal cancer	CAD, COPD, HLP, HTN	Yes	APR
16	71	M	26.7	Rectal cancer	DM, HLP, HTN	Yes	APR
17	84	F	25.7	Rectal cancer	HTN, GERD, CAD	Yes	APR
18	54	M	26.7	Recurrent anal cancer		Yes	APR
19	53	F	24.2	Recurrent anal cancer	Hepatitis C	Yes	APR + posterior vaginectomy
20	70	F	22.9	Paget's disease	HTN, CAD, DM	Yes	APR
21	48	M	26.5	Rectal cancer		Yes	APR
22	33	M	24.3	Crohn's disease		No	APR
23	49	M	28.1	Crohn's disease	DM	No	APR

CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; F, female; GERD, gastroesophageal reflux disease; HLP, hyperlipidemia; HTN, hypertension; M, male.

There was no significant difference in age, gender, BMI, primary disease, comorbidities, and history of radiation of those with or without complications (Table 4).

DISCUSSION

Reconstruction following APR or pelvic exenteration is challenging. These wounds are usually characterized by a noncompressible dead space, irradiated and poorly vascularized wound edges, and a large deficit in soft tissue, including skin and mucosa. Reconstructing these complex defects with healthy vascularized tissue can attenuate some of the aforementioned challenges and decrease wound healing complications.^{1,25} There are several options for reconstruction following APR. The VRAM flap has been the workhorse for perineal reconstruction because of its soft tissue bulk and reliable anatomy. Moreover, the efficacy of this flap has been validated by multiple studies.^{2,18,34} However, it is associated with abdominal morbidity, may not be an available option if the patient has had previous abdominal surgery, is not ideal in those requiring

multiple ostomies, and negates the benefits of minimally invasive resections.^{27,30,31} The pedicled gracilis muscle flap is another frequently employed option; however, it provides insufficient bulk for dead space obliteration.³⁵ A more attractive reconstructive solution may be offered by the ALT flap.

The ALT flap was first described by Song et al³⁶ in 1984. It has since been one of the most commonly used flaps for reconstruction of a wide range of defects.³⁷ Strengths include a robust vascular supply; a long pedicle and arch of rotation that will easily reach the perineum; low donor site morbidity; and the ability to incorporate skin, fat, fascia, and muscle.³⁷⁻⁴¹ The donor site does carry a risk of lower extremity weakness; however, in a prospective study by Hanasono et al,⁴² all 220 patients returned to their preoperative level of function after ALT harvest. Our experience corroborates this finding as both patients with lower extremity leg weakness had an unremarkable recovery.

Despite its advantages, the ALT flap has only recently been reported for use following APR. Although using the ALT for perineal reconstruction in general has been well described, to date, there are a relatively small number of reports assessing the use of the pedicled ALT specifically for reconstruction after APR or pelvic exenteration. Most notably, Pang et al⁴³ found that VRAM and ALT flap reconstructions were equivalent regarding postoperative complications, establishing the ALT flap as an acceptable alternative to the VRAM. In contrast, Nelson et al³⁴ compared 19 thigh flaps with 114 VRAM flaps and found a greater incidence of complications with the use of the thigh flap. Specifically, they found a higher incidence of donor site cellulitis, recipient site complications, pelvic abscess, and wound dehiscence. However, as noted by Pang et al,⁴³ the study by Nelson et al³⁴ lacked a uniform reconstructive modality and used a variety of thigh flaps not limited to the ALT.

Table 2. Patient Demographics (Summary)

	N = 23
Median age (IQR), y	66 (49-71)
Female, n (%)	7 (30.4)
Median BMI (IQR)	24.9 (24.2-26.7)
BMI > 30, n (%)	2 (8.7)
Primary disease, n (%)	
Rectal cancer	13 (56.5)
Anal cancer	5 (21.7)
Crohn's disease	4 (17.4)
Paget's disease	1 (4.3)
Comorbidities	
Diabetes mellitus	7 (30.4)
Hypertension	9 (39.1)
Coronary artery disease	4 (17.4)
Chronic obstructive pulmonary disease	2 (8.7)
Hyperlipidemia	4 (17.4)
Hepatitis C	1 (4.3)
Radiation therapy, n (%)	19 (82.6)

IQR, inter-quartile range.

Table 3. Postoperative Complications

Complications	N (%)
Patients with complications	9 (39.1)
Major complications	2 (8.7)
Sacral osteomyelitis	1 (4.4)
Donor site seroma	1 (4.4)
Urinary leak resulting in perineal wound dehiscence	1 (4.4)
Minor complications	9 (39.1)
Perineal wound dehiscence	6 (26.1)
DVT	1 (4.3)
Leg weakness (temporary)	2 (8.7)

Some patients experienced more than one complication.
DVT, deep vein thrombosis.

di Summa et al¹⁹ have used the ALT flap with fascia lata and vastus lateralis to reconstruct defects after extralevator APR in 6 patients. These authors noted superior muscle bulk of the ALT compared with that of the VRAM, when combined with fascia lata and vastus lateralis. Complications included 1 case of partial skin paddle necrosis (16.7%) and 1 case of wound dehiscence from recurrent disease (16.7%).

Wong et al³⁰ reported their experience with the ALT flap use after pelvic exenteration in a series of 18 patients. The most common complication in their series was minor perineal wound dehiscence, occurring in 33% of patients. Other complications included 1 patient with flap loss, 1 donor site wound infection, 1 enterocutaneous fistula, and an ileal conduit leak. Overall, they found that the ALT flap provided ample amount of well-vascularized tissue.

These 4 studies constitute the available published literature on the use of the ALT flap for reconstruction of APR or pelvic exenteration defects. These data have demonstrated that the ALT is a safe and effective option for reconstruction.

There are other series that report the use of the ALT flap for coverage of perineal and pelvic wounds, however, do not specifically address defects following APR or pelvic exenteration. Maxhimer et al³⁹ reported their experience with the ALT flap in 4 patients with inguinal (N = 2) and abdominal wall (N = 2) defects. Lannon et al⁴⁴ reported their experience using the pedicled ALT flap in the complex reconstruction of mostly groin defects from a variety of malignancies, including sarcomas and melanomas. Similarly, LoGiudice et al⁴⁵ published a series of 30 ALT flaps used for groin and lower abdominal reconstruction. Finally, Yu et al⁴⁶ published one of the first reports using ALT in perineoscrotal reconstruction in 2002.

In our series of 23 patients who have undergone reconstruction of APR or pelvic exenteration defects with ALT flaps, the most common complication was partial perineal wound dehiscence (N = 6; 26.1%). All wounds eventually healed with the exception of 1 case of sacral wound dehiscence and osteomyelitis. Our observations reflect that of Pang et al⁴³ and Wong et al,³⁰ in that perineal dehiscence appears to be the most common complication postoperatively. The majority of our patients underwent neoadjuvant radiation, which may explain the incidence of perineal dehiscence in our patient population. Although reconstruction of the pelvic/perineal defect with

Table 4. Comparison of Patient Demographics and Comorbidities for Wound Complications

	No Complication (N = 14)	Complication (N = 9)	P
Age, n (%)			0.214
<65	5 (35.7)	6 (66.7)	
>65	9 (64.3)	3 (33.3)	
Gender, n (%)			0.363
Female	3 (21.4)	4 (44.4)	
Male	11 (78.6)	5 (55.6)	
BMI, n (%)			0.1423
<30	14 (100)	7 (77.8)	
>30	0 (0)	2 (22.2)	
Diabetes mellitus, n (%)			0.657
No	9 (64.3)	7 (77.8)	
Yes	5 (35.7)	2 (22.2)	
Hypertension, n (%)			>0.999
No	9 (64.3)	5 (55.6)	
Yes	5 (35.7)	4 (44.4)	
CAD, n (%)			>0.999
No	12 (85.7)	7 (77.8)	
Yes	2 (14.3)	2 (22.2)	
COPD, n (%)			0.502
No	12 (85.7)	9 (100)	
Yes	2 (14.3)	0 (0)	
HLP, n (%)			0.127
No	10 (71.4)	9 (100)	
Yes	4 (28.6)	0 (0)	
Hepatitis C, n (%)			0.391
No	14 (100)	8 (88.9)	
Yes	0 (0)	1 (11.1)	
Rectal cancer, n (%)			0.102
No	4 (28.6)	6 (66.7)	
Yes	10 (71.4)	3 (33.3)	
Anal cancer, n (%)			0.343
No	12 (85.7)	6 (66.7)	
Yes	2 (14.3)	3 (33.3)	
Paget's disease, n (%)			>0.999
No	13 (92.8)	9 (100)	
Yes	1 (7.1)	0 (0)	
Radiation therapy, n (%)			0.26
No	1 (7.1)	3 (33.3)	
Yes	13 (92.8)	6 (66.7)	

CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; HLP, hyperlipidemia.

well-vascularized tissue serves to improve wound healing, it cannot be expected to completely mitigate the effects of radiation. This highlights the reconstructive challenge in this patient population.

We did not identify any significant differences in the age, gender, BMI, primary disease, comorbidities, and history of radiation in those with or without complications. This is surprising because obesity, diabetes, and radiation exposure have been reported to impair wound healing. An association would potentially bear out with a larger sample size.

More specific to reconstruction after APR and pelvic exenteration is the large dead space component. Although other reports have addressed this, we believe our report highlights that the ALT flap, particularly when harvested with vastus lateralis muscle, can obliterate large dead spaces. Importantly, the flap can effectively be tailored to the defect by taking only the bulk of vastus lateralis necessary. Successful dead space obliteration is evidenced by the lack of pelvic abscess formation observed in our patient population. Importantly, flap inset into the pelvis can be facilitated by utilizing sutures

placed by the colorectal surgery team to parachute the flap into the desired location.

Previously, Pang et al⁴³ reported that VRAM and ALT flap reconstructions were equivalent with respect to postoperative complications. Although we did not perform a head-to-head comparison of flap types in this study, a discussion of a previous study from our institution may shed some light on this issue. In a retrospective series that included 37, 18, and 10 patients who underwent reconstruction with a VRAM, gracilis, and gluteal fasciocutaneous flap, respectively, Miller et al⁴⁷ noted an overall complication rate of over 60% and a donor site complication rate of 25%. In comparison, the overall and donor site complication rates in this study were more favorable.

We have invested considerable effort in other areas of reconstructive surgery to minimize abdominal wall morbidity, such as with muscle-sparing and perforator-based approaches in breast reconstruction.^{48,49} Yet, with perineal reconstruction, we seem to take it for granted that the patient will incur abdominal wall morbidity. In line with the philosophy of “do no harm,” we believe that the ALT allows for a similar reconstructive outcome while bypassing the abdominal wall morbidity associated with the use of VRAM flaps.

Limitations of the present study include its retrospective design, relatively small number of patients, and lack of a control group. Yet, our series is large relative to what has been published, particularly in light of its focus on reconstruction following APR and pelvic exenteration. Certainly, larger prospective studies with head-to-head comparisons would be highly valuable in further elucidating the role of the ALT flap within the reconstructive algorithm of pelvic reconstruction.

In conclusion, APR and pelvic exenteration result in large soft tissue defects with considerable noncollapsible dead space within an (often) irradiated field. In light of the frequent need for secondary ostomy revisions, attempts to minimize abdominal wall morbidity appear prudent. The value of the ALT flap in this context has been underreported. Although other reports have in part addressed these reconstructive challenges, we believe our report highlights the value of the ALT flap as a first-line reconstructive option following APR or pelvic exenteration.

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