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ARTICLE

Surgical flap delay to allow primary transabdominal transplantation of extended rectus abdominis myocutaneous flaps in increasingly complex pelvic wound reconstructions

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ABSTRACT

Primary intra- or transabdominal transplantation of an extended rectus abdominis myocutaneous (ERAM) flap may help prevent surgical complications of pelvic resections. Surgical delay of the ERAM flap may help prevent intra-abdominal (partial) flap loss after transplantation in highly complex situations including previous irradiation. We report on the outcome of this approach and the risk-factors associated with an eventful outcome. From 2012 to 2020, 105 delayed ERAM flaps were consecutively applied immediately following extended pelvic resections after chemoradiation or hyperthermic intraperitoneal chemotherapy. We addressed the increased reconstructive demands by designing the flap in line with the 10th rib and delaying the flap's skin island. All post-operative complications were assessed in light of patient-related or procedure-related potential risk-factors. Major complications occurred in 39 patients. These were correlated with surgery for residual or recurrent malignancy ($p < 0.01$), with tip necrosis after flap delay ($p = 0.02$), and with the use of a mesh to close the abdominal donor site ($p < 0.01$). (Partial) flap loss occurred in 4 cases. We observed a comparably high rate of major complications after ERAM transplantations for increasingly extending indications of perineal-pelvic resections. We consider this to be attributable to poorer patients' conditions and disease processes, rather than to flap viability. Delay of the flap allowed for the use of large and voluminous flaps with comparably little (partial) flap loss.

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Introduction

Perineal wound closure after abdominoperineal resection of the rectum (APR) or pelvic exenteration features high rates of surgical complications, particularly following previous radiotherapy [1–3]. Compared to direct approximation, primary application of a rectus abdominis myocutaneous (RAM) flap has been shown to reduce post-operative pelvic and perineal morbidity by obliteration of the resulting pelvic dead space and replacement of the resected perineal tissues [2,4–6]. This flap can be designed with a transverse (TRAM), a vertical (VRAM), or an extended skin island (ERAM) [7,8]. Compared to the VRAM or TRAM flap, the extended design offers less bulk in its pedicle, a greater arc of rotation, a larger skin paddle, and a smaller fascial defect [2–4,9,10]. To date, three series were reported of primary intra- or transabdominal ERAM transplantation in complex pelvic wound reconstructions [2–4]. These series featured up to 31 patients, all of whom had been operated on up to 2010.

Working in a comprehensive cancer center, we have been confronted with increasingly complex perineo-pelvic resections resulting from extending indications for ablative surgery and concurrent (neo) adjuvant treatment including previous irradiation. Over 15 years ago, we started addressing these increasing demands by the extension and a surgical delay of the ERAM's skin paddle prior to primary transabdominal transplantation. Such routine delay of the ERAM flap has not been presented previously. We report on the outcome of this approach and the risk-factors associated with an eventful outcome in a large series of patients treated this way.

Methods

Patients

From January 2012 to January 2020, 105 pedicled ERAM flaps were consecutively applied for combined perineal-pelvic surgery and reconstruction in 62 men and 43 women with a mean age of 63 years (range, 28–80 yrs; SD 10.8) and a mean body mass index of 26.0 kg/m^2 (18.4–39.4 kg/m^2; SD 4.53) (Table 1).

Seventy-four patients were operated on for recurrent or residual tumor after previous chemo-radiotherapy ($n = 30$), surgery ($n = 7$), or a combination of both ($n = 37$), whereas 17 patients were operated on for a primary malignancy. All 17 primarily operated patients and 29 of the 74 patients operated on for a recurrent or residual tumor received neoadjuvant chemoradiation therapy before combined resection and ERAM transplantation.

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Table 1. Number (and percentage) of patient-related characteristic in our series of 105 patients.

Characteristic	Number of patients (percentage)
Male	62 (59)
Current tobacco abuse	22 (21)
Diabetes mellitus[a]	11 (10)
Cardiovascular disorder	34 (32)
Residual or recurrent tumor	74 (71)
Origin of primary tumor	
gastro-intestinal	80 (76)
urological	15 (14)
gynecological	10 (10)
Pre-existing ostomy	
colostomy	47 (45)
urostomy	1 (1)
both	2 (2)
Anus previously resected	13 (12)
Prior/pre-op chemoradiation	104 (99)[b]

[a]Diabetes mellitus was controlled in all.
[b]The one remaining patient had had hyperthermic intraperitoneal chemotherapy (HIPEC).

The remaining 14 patients were operated on for rectovaginal, rectourethral, or vesicovaginal fistula ($n = 9$), a presacral abscess ($n = 3$), or a perineal hernia ($n = 2$) resulting from previous oncologic treatment including chemoradiation. In all, 104 patients had had chemoradiation therapy prior to surgery. The remaining patient had previously had hyperthermic intraperitoneal chemotherapy (HIPEC) [11]. Previous surgery had included resection of the anus in 13 patients.

Pre-operative planning

In the 48 patients who presented with either a colostomy ($n = 47$) or urostomy ($n = 1$) resulting from previous interventions, and in those in whom either a colostomy or a urostomy was planned as part of the APR or exenteration, the ERAM was preferably harvested from the contralateral site [9]. Still, presence of a ostomy is not considered a contraindication for an ipsilateral ERAM flap. In the 2 patients presenting with both a colostomy and a urostomy, as well as in cases of scarring of the donor side from previous surgery, the continuity of the inferior epigastric vascular pedicle from groin up to the peri-umbilical perforators was routinely assessed using preexistent abdominal images [12]. Additional CT-angiography was performed only in cases where previous imaging was considered inadequate to allow assessment of this vascular supply [4,8]. This was done in 9 cases including a preexistent unilateral colostomy or urostomy combined with contralateral scars ($n = 3$), preexistent bilateral scarring ($n = 2$), or preexistent bilateral ostomies ($n = 1$) [8]. The indications for the three remaining angiographies could not be objectified.

The ERAM flap was designed based on hand-held Doppler detection of the peri-umbilical perforators of the inferior epigastric vascular pedicle. This way, any lateral displacement of the perforators resulting from divarication of the rectus abdominis muscles can be recognized [7]. Neither the Doppler, nor the preoperative vascular imaging was applied to identify possible dominant perforators. The flap's skin paddle was designed in line with the tenth rib, along the inferior costal arc (Figure 1) [8]. The pinch test was used to determine the maximum width of the skin paddle and care was taken to plan the inferior border of the flap cranially to the level of the arcuate line of the deep rectus fascia [7]. Laterally, the flaps extended to the mid-axillary or posterior axillary line, depending on the pinch test indicative of wound closure free of tension. In order to allow harvesting and wound closure in supine position no flap was designed past the posterior axillary line.

Figure 1. View of a 8 × 28 cm ERAM flap, 4 days after its delay and one day prior to total exenteration with ileal urinary conduit in a 71-year-old man with a second recurrence of prostate carcinoma, 7 years after external beam radiotherapy and hormonal therapy, and 2 years after brachy-radiotherapy for a first recurrence. Additionally, the patient underwent near-total colectomy and an ileostomy for ulcerative colitis, 6 years ago. Current indication for surgery is pain, bleeding, and necrosis of the prostate region and distal bladder, for which a suprapubic urinary deviation catheter has been placed. The flap is to be taken from the left side because of the ileostomy with parastomal hernia, at the right. The large ink dot caudally to the flap represents the suggested location of the second stomy to be made. Note that our design of the flap's skin paddle is in line with the tenth rib along the inferior costal arc, rather than more oblique along the axis of the eighth rib.

Surgical technique

Flap delay

A minimum of three days prior to flap transplantation, surgical delay of the skin paddle of all flaps was performed to allow its increase in size and volume and to prevent (partial) necrosis once the flap is brought intra-abdominally [9,13]. This delay was performed a mean of 5.3 days (range, 3–14 days; SD 1.57) before transplantation in 104 of the flaps, and depended on logistic considerations and theatre availability. Transplantation of the one remaining flap was postponed 4 months to still allow chemotherapy prior to ablative surgery.

The pre-marked skin island was fully circumcised down to the linea alba and the fascia of the oblique abdominal and rectus abdominis muscles. Mean length of the skin paddle was 29.4 cm (range, 20–42 cm; SD 5.23) and its width, 9.7 cm (range, 6–16 cm; SD 2.04). The flap was raised from the fascia from lateral to

Table 2. Number (and percentage) of procedure-related characteristic in our series of 105 patients.

Characteristic	Number of patients (percentage)
Ablative oncologists involved[a]	
Lower gastro-intestinal surgeon	100 (95)
Urologist	54 (51)
Gynecologist	11 (10)
Elements of oncological interventions	
New or revised colostomy	64 (61)
Ilial or colonic urinary conduit	44 (42)
Urinary track repair	7 (7)
Anus resection	76 (72)
Coccygeus/sacrum resection	32 (30)
Intra-operative radiotherapy	10 (10)
HIPEC	2 (2)
Reconstructive surgery	
Right-sided donor site	78 (74)
Tip necrosis after delay	27 (26)
Fully de-epithelialized flap	64 (61)
Additional perineal flap(s)	4 (4)
Mesh closure of donor site	26 (25)

[a]Numbers add up to 165 because 2 ($n = 52$) or 3 ($n = 4$) ablative disciplines were involved.
HIPEC: hyperthermic intraperitoneal chemotherapy.

medial until the lateral border of the rectus sheet was reached. The superficial rectus fascia was subsequently incised along the superior border of the skin island to locate the lateral border of the rectus abdominis muscle and to allow careful medial dissection until the perforators were encroached [5,8,10]. Division of the superior epigastric vascular pedicle for additional vascular delay was not routinely performed. The superior fascial incision was re-approximated and the skin island was sutured in its original position over a Redon drain that was left until flap transplantation.

Laparotomy and flap transplantation

Midline laparotomy APR ($n = 42$), pelvic exenteration ($n = 58$), resection of presacral metastasis ($n = 2$), pelvic reduction of perineal hernia ($n = 2$), or sole debridement of a chronic presacral abscess ($n = 1$) was performed by a mostly multidisciplinary team of ablative oncologists (Table 2) and occasionally combined with intra-operative additional radiotherapy ($n = 10$) or HIPEC ($n = 2$) [11]. The anus was resected as part of this procedure in 76 of the 105 patients (0.72), and newly made or revised colostomies ($n = 40$), urostomies ($n = 20$), or both ($n = 24$) were brought through and fixed in the abdominal wall. Consequently, 58 patients had a colostomy or a urostomy whereas the remaining 47 patients had both a colostomy and a urostomy at the end of the combined procedure. Ureteral re-anastomosis ($n = 4$), (partial) bladder resection ($n = 3$), or unilateral ureteronephrectomy ($n = 1$) was performed in eight patients.

Following the resection, the ERAM flap skin paddle was lifted from the oblique abdominal muscular fascia by the plastic surgeon. Necrosectomy of the tip was indicated in 27 flaps (0.26), resulting in a mean residual length of 28.2 cm (range, 20–42 cm; SD 4.99) of the 105 flaps to be transplanted (Table 2). The anterior lamina of the rectus sheet was opened circumferentially to the subcutaneous cuff protecting the perforators. We make a point of leaving enough of the caudal part of the anterior lamina to generously overlap with the linea arcuate of the posterior lamina in order to later allow double-breasted closure [7]. The rectus muscle was dissected caudally down to the level of its inguinal vascular pedicle. In four patients, a pre-existent colostomy ($n = 3$) or urostomy ($n = 1$) was temporarily taken down to allow dissection of the vascular pedicle 'flush' on the ostomy.

Depending on the reconstructive demands, the flap was partly de-epithelialized and transplanted trans-abdominally for perineal wound closure or vaginal reconstruction ($n = 41$) [3,4], or completely de-epithelialized to be used intra-abdominally for pelvic fibromuscular diaphragm reconstruction or filling of the pelvis ($n = 64$) [7,10]. The mean de-epithelialized area of the 41 partly de-epithelialized flaps comprised 78% (range, 20–95%; SD 20.6) of the skin paddle surface.

The pelvic fibromuscular diaphragm could be primarily closed in 10 of the 64 patients with a completely de-epithelialized flap. In these patients, the flap was used solely to fill the pelvis with well-vascularized tissue. The dermis of remaining 54 completely de-epithelialized flaps was sutured circumferentially to the remnants of the pelvic diaphragm to prevent herniation. No reinforcement of the pelvic diaphragm by synthetic or biodegradable mesh was performed in any of our patients. In two of these 64 patients, bilateral gluteal fold flaps were additionally used primarily to close a perineal defect [14].

Abdominal donor site closure started by double-breasted *vest-over-pants* suturing of the arcuate line of the posterior lamina of rectus sheet to the inferior remnant of the anterior lamina resulting after flap harvesting [7]. The remaining lateral and cranial edges of the anterior lamina defect were, likewise, sutured onto the posterior lamina. Such primary fascial closure may well be achieved in most patients [4,8]. A mesh to prevent cicatricial herniation was sutured in between both layers only in cases where the quality and quantity of both the inferior superficial rectus fascia and the superior deep rectus fascia were deemed insufficient to allow adequate double-breasted closure [8,9]. The decision to do so was left to the discretion of the plastic surgeon operating. Consequently, a mesh was applied in 14 of the 43 female patients (0.33) and 12 of the 62 male patients (0.19) ($p = 0.13$). Of these, five men and two women were operated on by the one plastic surgeon who routinely applied a mesh in all cases.

The skin paddle donor site was subsequently closed primarily after mobilization of its edges. Only after such rearrangement of the abdominal fascia and integument, was any ipsilateral ostomy brought through and set into the abdominal wall. Finally, the midline abdominal wound was closed. The follow-up after this combined procedure averaged 38 months (range, 3–90 month; SD 22.3) in the 55 patients surviving to date (0.52).

Data gathering and analysis

Outcome measures

All donor site, receptor site, or intra-abdominal complications, unscheduled surgical re-interventions, and (partial) flap losses were recorded as outcome measures of surgical therapy. Differentiation was made between minor and major complications. Minor complications were defined as complications that were treated conservatively, whereas events that necessitated unscheduled surgical re-interventions or vacuum assisted closure (VAC) therapy were regarded major complications.

Statistical analysis

We assessed the influence of patient-related (Table 1) and procedure-related potential risk-factors (Table 2) by comparison of the prevalence of major complications among those with the characteristic, to those without the characteristic by use of the Chi squared test for categorical data [15]. *P*-values of 0.05 or less were considered statistically significant.

Table 3. Number (and percentage) of patients with characteristic among patients with a major complication compared to that among patients without a major complication.

Potential risk factor	Major complication ($n = 39$)	No major complication ($n = 66$)	p Value
Patient characteristics			
Tobacco abuse	9 (23)	13 (20)	0.68
Cardiovascular disorder	11 (28)	23 (35)	0.48
Residual or recurrent tumor	33 (85)	41 (62)	**0.00**
Preexistent infection	6 (15)	15 (23)	0.37
Surgical procedure			
Exenteration	25 (64)	33 (50)	0.16
APR	13 (33)	29 (44)	0.28
Other procedure	1 (3)	4 (6)	0.42
Elements of surgical procedure			
New or revised colostomy	21 (54)	43 (65)	0.25
Ilial or colonic urinary conduit	20 (51)	24 (36)	0.14
Urinary track repair	2 (5)	5 (8)	0.63
Anus resection	26 (67)	50 (76)	0.34
Intra-operative radiotherapy	4 (10)	6 (9)	0.84
Elements of reconstructive procedure			
Tip necrosis after delay	15 (38)	12 (18)	**0.02**
Fully de-epithelialized flap	24 (62)	40 (61)	0.93
Mesh closure of donor site	16 (41)	10 (15)	**0.00**

Statistically significant p-values are provided in bold print.
APR: abdomino-perineal rectum resection.

Results

The surgical outcome of the combined procedure was uneventful in 38 patients (0.36). In 39 of the 67 patients with an eventful outcome the complications observed necessitated unscheduled repeat surgery or VAC therapy (Table 3). We found these major complications to correlate significantly with surgery for a residual or recurrent malignancy ($p = 0.00$), with tip necrosis after flap delay ($p = 0.02$), and with the use of a mesh to close the abdominal fascial donor site ($p = 0.00$), but not with increased age or BMI, or the length of delay.

In the following, we distinguish between complications observed in the ERAM flap, at the flap's donor site, at the receptor site, and intra-abdominally. Intra-abdominal complications were related to the surgical, urological, or gynecological interventions rather than the reconstructive procedure.

ERAM flap outcome

After transplantation, we observed necrosis of the entire skin paddle in 1 of the 64 fully de-epithelialized flaps and partial skin paddle necrosis in 3 of the partially de-epithelialized flaps (Table 4). Three out of 4 of these cases occurred in the 22 current smokers ($p < 0.01$). None were associated with tip necrosis after the delay procedure. Necrosectomy and primary wound closure ($n = 1$), VAC therapy ($n = 1$), or additional unilateral gluteal fold flap transplantation ($n = 1$) were performed. Necrosis in the fourth patient was superficial and left to heal by secondary intention.

Absence of necrosis in the remaining 63 fully de-epithelialized and intra-abdominal flaps could be objectified on postoperative imaging studies in all and, additionally, during subsequent laparotomy in 15 of the 63 patients.

Flap donor site outcome

Donor site complications occurred in 20 patients, sixteen of whom needed unscheduled surgery or VAC therapy (Table 4). Any statistically significant correlation between the risk-factors and these complications could not be objectified.

Table 4. Outcome of the 105 combined ablative and reconstructive interventions.

Outcome measure	Total	Major complication	Minor complication
ERAM flap			
partial necrosis[a]	4 (4)	3 (3)	1 (1)
Flap donor site[b]			
infection	5 (5)	3 (3)	2 (2)
skin necrosis	6 (6)	5 (5)	1 (1)
skin dehiscence	5 (5)	5 (5)	0 (0)
fascial dehiscence	6 (6)	4 (4)	2 (2)
Flap receptor site			
infection	2 (2)	1 (1)	1 (1)
skin necrosis	9 (9)	4 (4)	5 (5)
skin dehiscence	19 (18)	4 (4)	15 (14)
perineal hernia	3 (3)	2 (2)	1 (1)
Intra-abdominal[c]			
infection	16 (15)	11 (10)	5 (5)
enteral necrosis	2 (2)	2 (2)	0 (0)
enteral anastomosis leak	4 (4)	4 (4)	0 (0)
urinary diversion leak	9 (9)	2 (2)	7 (7)
other events	9 (9)	6 (6)	3 (3)

The total number (and percentage) of complications is differentiated according to the number of resulting re-interventions and VAC therapies (*major complications*) versus the number of conservative treatments (*minor complications*).
[a]Necrosis of the entire skin paddle ($n = 1$) 20% lateral tip skin paddle necrosis ($n = 1$), 30% marginal skin paddle necrosis ($n = 1$) and superficial skin necrosis ($n = 1$).
[b]Major donor site infection, integumental dehiscence, and fascial dehiscence (*platzbauch*) was concomitantly noted in 1 patient and minor infection and a major integumental dehiscence in another. This resulting in a total of 23 donor site complications noted among 20 patients.
[c]Likewise, a total of 40 intra-abdominal complications were observed in 33 patients.

Short-term fascial dehiscence ($n = 4$) or long-term abdominal herniation ($n = 2$) occurred in 3 women and 2 men in the group of 26 patients in whom a mesh was applied at abdominal fascial closure (0.19), and in 1 of the 79 cases of closure without a mesh (0.01) ($p < 0.01$). This implies that the decision *not* to apply a mesh may reliably be made. Mesh application was found not to correlate with increased age or BMI. Three short-term dehiscences presented as a *platzbauch* associated with paralytic enteral distension ($n = 1$), an infected mesh ($n = 1$), or intra-abdominal urinary leakage ($n = 1$). The fourth short-term fascial dehiscence was associated with paralytic enteral distension and was limited to subcutaneous enteral herniation. No cause could be specified for the long-term hernias. The 3 cases of *platzbauch* and the 1 hernia occurring without the initial use of a mesh necessitated surgical re-intervention, whereas the remaining two hernias could be managed conservatively.

Flap receptor site outcome

We observed receptor site complications in 33 patients, eleven of whom needed additional surgery or VAC therapy (Table 4). In 2 patients, perineal wound healing problems necessitated unscheduled addition of a gluteal fold flap or a lumbar flap after 2 days, respectively 7 months. Perineal herniation occurred in 1 of the 64 patients in whom the flap had been fully de-epithelialized and in 2 of the 41 patients in whom part of the skin paddle had been inserted into the perineum ($p = 0.32$). In one, the herniation could be successfully corrected surgically, 5 months post-transplantation. In the second, 2 subsequent surgical corrections did not prevent the herniation from recurring. Surgical correction was not indicated in the third patient.

Table 5. Comparison of our current series with the three previously reported series of primarily transabdominal ERAM flap transplantations for complex pelvic wound reconstructions.

	Bell et al. [4]	Abbott et al. [2][b]	Combs et al. [3]	Current series
Study years	1999–2003	2002–2005	2001–2009	2012–2019
Number of patients	31	16	22	105
Mean age (range)	55 year (30–77)[a]	58 year (40–78)	60 year (n.r.)	63 year (28–80)
Pre-op radiotherapy (percentage)	21 (68)	8 (50)	19 (86)	105 (100)
Pre-op chemotherapy (percentage)	18 (58)	n.r.	n.r.	105 (100)
Number of APR *vs.* exenteration	30 *vs.* 0	8 *vs.* 4	10 *vs.* 10	42 *vs.* 58
ERAM extension	n.r.	anterior axillary line	anterior axillary line	posterior axillary line
Mean skin paddle length (range)	18 cm (12–25)[a]	21 cm (16–25)[c]	n.r.	28 cm (20–42)
Abdominal mesh (percentage)	0 (0)	n.r.	7 (37)[d]	26 (25)
Mean follow-up (range)	9 months (1 – 27)[a]	17 months (1–57)[a]	15 months (n.r.)	36 months (3–90)
Uneventful outcome (percentage)	15 (48)	9 (56)	n.r.	38 (36)
(Partial) flap loss (percentage)	3 (10)	2 (13)	2 (11)[d]	4 (4)
Abdominal weakness (percentage)	2 (7)	n.r.	n.r.	6 (6)

[a]Median instead of mean.
[b]This series includes six cases already reported by Lee et al. [10].
[c]The six cases already reported by Lee et al. [10].
[d]Approximation of outcome in 18 flaps used for primary complex pelvic wound reconstruction that were not left fully intra-abdominally.
n.r.: not reported.

Intra-abdominal surgical outcome

A total of 40 intra-abdominal complications were observed in 33 patients, 21 of whom needed unscheduled surgery (Table 4). Post-operatively, a presacral abscess occurred in six of the 41 patients in whom the ERAM flap was partly de-epithelialized to replace a perineal defect and in one patient in whom the flap had been fully de-epithelialized to fill up the pelvic dead space ($p = 0.01$) None of these seven patients underwent the combined procedure for a preexisting presacral abscess.

Among the 33 patients with intra-abdominal complications we did not observe more extra-abdominal complications than among the 72 patients without intra-abdominal complications (0.33, respectively 0.47; $p = 0.18$)

Oncologic outcome

To date, 61 patients (0.58) were diagnosed with locally residual or recurrent disease or distant metastases, on average 7.8 months after combined ablation and ERAM transplantation (range, 0–36 months; SD 7.13). Forty-one of these 61 patients underwent repeat surgery ($n = 7$), radiotherapy ($n = 7$), systemic therapy ($n = 23$), or a combination of these ($n = 4$).

Fifty of the 105 patients died of recurrent or residual disease ($n = 49$) or of non-oncological ($n = 1$) causes, on average 16.3 months post-operatively (range, 2–82 months; SD 15.32).

Discussion

In our series of 105 patients, we observed an uneventful outcome in 38 per cent of patients. This compares unfavorably to the 48 to 56 per cent uneventful outcome reported in smaller series of patients treated prior to 2010 (Table 5) [2–4]. However, neither preexistent colostomies, nor multidisciplinary ablative teams were mentioned in these reports. Additionally, the fractions of patient having previously undergone chemoradiation and the fractions of an APR or exenteration were smaller. It appears that, working in a tertiary referral center, we observed a relatively high rate of complications because we reconstruct more complex pelvic wounds in multidisciplinary treated patients with poorer pre-operative condition [10]. Accordingly, we found our major complications to be correlated with surgery for a residual or recurrent malignancy, with tip necrosis after flap delay, and with the use of a mesh for abdominal wound closure. We consider these 3 characteristics to equally reflect the patients' relatively poor general condition and disease process.

To address the extension of indications for pelvic ablative surgery we, furthermore, apply ERAM flaps of larger size and bulk than those previously reported flaps (Table 5). Even so, we observed comparably little (partial) flap loss ($n = 4$), which is the most relevant outcome of flap-based reconstructive surgery. We consider the horizontal design and surgical delay of the flaps to have allowed for this comparably favorable outcome of the use of larger flaps in more complex defects. The skin paddle is designed parallel to the 10th rib, rather than more oblique and parallel to the 7th rib [7,8]. First, the vascularization over the 10th rib is superior to that over the 7th rib. This was originally observed by Taylor et al. [7] and confirmed by Lee et al. [10]. Second, the abdominal subcutis included parallel to the 10th rib tends to be more voluminous than the purely thoracic subcutis overlying the 7th rib. Unlike Combs et al. [3] we feel that inclusion of this larger subcutaneous volume results in more bulk than may be achieved with the VRAM flap. Third, the entire length and arc of rotation of the oblique design can be preserved by lateral extension of the horizontal skin island to the midaxillary or [5,7,8,16], even, posterior axillary line, rather than the anterior axillary line [2,3,10]. The initial length of the 27 flaps in which tip necrosis appeared (mean 31.2 cm, range 23–42 cm) differed significantly from that of the other 78 (mean 28.6 cm, range 20–42 cm) ($p = 0.05$). Still, the statistically critical length of flaps seems to be 36 cm with significantly more flaps of and above that length showing tip necrosis than under that length ($p = 0.05$). In most patients, this allows a flap designed well past the midaxillary line to ensure maximal flap volume and surface.

Classen already suggested that such extension of the flap's skin paddle might be safely achieved by a delay procedure [16]. Surgical delay is performed either 1- to define the survival length of an unknown flap, 2- to improve the circulation to a known flap to combat the insult of a kink or twist when the flap is transferred, or 3- to increase the survival length of a known flap [9,17]. The delay allowed for a mean skin paddle length of 28 cm of flaps to be transplanted, rather than 18 to 21 cm (Table 4) [3,4]. We now even feel that any flap that showed no tip necrosis could potentially have been designed longer primarily. Because we resect possibly ischemic parts prior to transplantation, such extension can safely be done without increased risk of intra-abdominal necrosis after transplantation.

Reporting on only one case of partial necrosis in a series of 18 ERAM flaps (0.05) Parrett et al. [5] remarked that given the increased length-to-width ratio of the extended design, they might have found a higher rate of edge necrosis with a larger patient number. However, the length-to-width ratio of the 27 flaps in which we observed tip necrosis (mean 3.14, range 2–4) did not differ significantly from that of the 78 flaps that showed no tip necrosis (mean 3.08, range 2–5) ($p = 0.68$). Our comparable fraction (0.04) of (partial) necrosis in a much larger series proves that this use of the ERAM flap may be implicitly reliable. Because its bulk has a greater arc of rotation than any bulk immediately overlying to the muscle, we prefer this use to fill up the pelvic cavity and reach the pelvic floor or perineum.

Conclusions

We observed a comparably high rate of major complications after ERAM transplantations for increasingly extending indications of perineal-pelvic resections. We consider this to be attributable to poorer patients' conditions and disease processes, rather than to flap viability or reconstruction. We addressed the increased reconstructive demands by designing the flap in line with the 10th rib and delaying the flap's skin island to prevent intra-abdominal necrosis after transplantation. This allowed for extension of the lateral design of the skin island to obtain more flap volume and surface without any increase of (partial) flap loss.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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