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ORIGINAL ARTICLE

Flaps of the abdominal wall

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Received: 1 June 2024, Accepted: 11 August 2024,
Published online: 30 September 2024

ABSTRACT

Objective: The deep inferior epigastric artery perforator (DIEP) and transverse-vertical rectus abdominis myocutaneous (TRAM, VRAM) flaps are derived from the anterior abdominal wall and can be free or pedicled. This study aimed to analyze the differences in postoperative complication rates among various types of abdominal flaps and to assess the impact of chemotherapy (CT) and radiotherapy (RT) on surgical outcomes.

Materials and Methods: A retrospective study was conducted, analyzing abdominal flap operations performed between 2016 and 2023. Data on demographics, defect location, mesh use, and postoperative chemo-radiotherapy were collected. Quantitative variables were evaluated as means, minimum-maximum values, and categorical variables were assessed as percentages.

Results: A total of 37 patients underwent 38 operations. Of these, nine patients had pedicled TRAM flaps, 16 had free-TRAM flaps, 6 had free DIEP flaps, and 6 had VRAM flaps. The defect locations were predominantly for breast reconstruction (81.08%), followed by head and neck (8.1%), extremity (8.1%), and thoracic wall (2.7%). The overall donor site complication rate was 5.4%, and the flap site complication rate was 13.51%. The lowest donor site complications were observed in the free-TRAM and VRAM groups (0%), while the highest were in the DIEP group (16.66%). The lowest flap site complication rate was 0% in the free-TRAM group, and the highest was 33.33% in the VRAM group. Donor site complication rates were similar between the mesh-used (5.88%) and non-mesh-used (5%) groups. All donor site complications occurred in patients who received postoperative CT and RT.

Conclusion: Abdominal flaps were primarily utilized for breast reconstruction. The free-TRAM group exhibited the lowest donor and flap site complication rates, while the DIEP group had the highest donor site complication rates. Mesh use did not affect donor site complication rates. Postoperative administration of CT and RT was associated with increased donor site complications.

Keywords: Abdominal Wall, Free Tissue Flaps, Microsurgery, Musculocutaneous Flap, Pedicled Flap, Perforator Flap.

INTRODUCTION

The abdominal wall has been used as a flap donor site to reconstruct various defects. Flaps harvested from the abdominal wall have been used mainly in autologous breast reconstruction; nevertheless, the abdominal wall can be used in many oncologic, traumatic, or various settings such as head and neck [1,2], upper [3] and lower [4] extremity, gynecological [5,6] and penoscrotal reconstruction [7]. The rectus abdominis myocutaneous (RAM) flap was first defined by Mathes and Bostwick in 1977 [8, 9]. Later, in 1979, Robbins described the pedicled vertically oriented RAM (VRAM) flap for breast reconstruction [10]. Holmström, in 1979, described essentially the transversely oriented RAM (TRAM) flap [11]. Later, in 1982, Hartrampf described a pedicled TRAM flap [12]. In order to decrease donor site morbidity and to reduce the muscle bulk, the deep inferior epigastric artery perforator (DIEP) flap was described in 1989 by Koshima and Soeda for defects in the groin and oral cavity [13] and in 1994 by Allen and Treece for breast reconstruction [14].

Abdominal flaps are versatile and trustworthy but bear certain complication risks. Complications can be observed related to the flap site or donor site. Microvascular complications and other flap site complications are generally related to primary complications, and donor site complications are frequently underreported. Following the removal or damage of the rectus abdominis muscle, its nerves and fascia, or intercostal nerves, the abdominal wall is weakened [15], and abdominal bulges or hernias can occur. Multiple studies have shown that regarding donor site complication rates, the TRAM flap has the highest rates, while the DIEP flap has the lowest rates. However, differences regarding microvascular and flap-related complications among various abdominal flaps remain controversial [15,16].

This study analyzed abdominal flap operations performed in a single clinic. Patient characteristics, defect location, timing of the reconstruction surgery, postoperative treatment, and postoperative complication rates were investigated. We aimed to demonstrate differences between postoperative complication rates of different types of flaps and show the effect of chemotherapy and radiotherapy on surgical outcomes.

MATERIALS AND METHODS

A retrospective analysis was conducted on abdominal flap procedures performed between 2016 and 2023, totaling 37 operations. Demographic data, comorbidities, defect locations, and donor site closure techniques (including using meshes) were recorded. Additionally, postoperative chemotherapy and radiotherapy records were analyzed for patients with primary malignant diseases.

Exclusion criteria

Immediate breast reconstruction cases were excluded from the analysis. Flaps from the anterior abdominal wall other than TRAM, DIEP, and VRAM, such as free superficial circumflex iliac artery perforator (SCIP) flaps or pedicled SCIP flaps, were also excluded. Flaps from the lateral or posterolateral abdominal wall were similarly excluded.

Statistical analysis

Following data collection, variables were entered into the Statistical Package for Social Sciences for Windows SPSS 23.0 (IBM Corporation, Armonk, New York, United States). Pearson's chi-square test and Fisher's exact test were employed to evaluate categorical data (presence of complications). Quantitative variables were expressed as means, with minimum and maximum values noted. Categorical variables were presented as percentages. Analysis was conducted at a 95% confidence level, with p-values < 0.05 deemed statistically significant.

RESULTS

Between 2016 and 2023, 37 patients underwent surgery involving 38 flaps. Among them, 30 patients underwent breast reconstruction, while three patients each underwent head & neck and extremity reconstruction, and one patient underwent chest wall reconstruction. The flaps comprised 6 DIEP, 25 TRAM, and 6 VRAM flaps. The mean age of the 37 patients was 46.1 years, ranging from 20 to 63. The average hospitalization duration was 12 days, ranging from 5 to 90 days. Out of 37 operations, two donor site-related complications (5.4%) and five flap-related complications (13.51%)

were observed. Of the patients, 24 (64.86%) received adjuvant postoperative radiotherapy (RT), and 30 (81.08%) received postoperative chemotherapy (CT). Information regarding mesh use during donor site closure revealed that polypropylene mesh was used in 17 operations (45.94%) while not in the remaining 20 operations (54.05%). Patient data is summarized in Table 1.

Nine of the 25 TRAM flaps were pedicled, and 16 were free flaps. All pedicled TRAM flaps were supercharged with an additional vein anastomosis (superficial inferior epigastric vein to cephalic vein). Among pedicled TRAM patients, one was bilateral, while others were unilateral. The average age at surgery was 44.5 years, and the average hospitalization duration was 8.8 days. Mesh was used during donor site closure in 5 patients (55.55%) and not in 4 patients (44.44%). Complications in pedicled TRAM flaps included donor site dehiscence (11.11%), microvascular complications necessitating revision surgery (11.11%), and flap site dehiscence treated with a pedicled latissimus dorsi myocutaneous flap (11.11%). Among patients in the pedicled TRAM group, 77.77% received adjuvant postoperative RT, and 88.88% received adjuvant postoperative CT.

Fifteen free TRAM flap surgeries were performed for breast reconstruction, and one was performed for upper extremity reconstruction due to a traumatic arm defect. The average patient was 44.7 years, and the mean hospitalization duration was 9.12 days. Mesh was used during closure of the donor site in 8 patients (50%) and not in the other eight patients (50%). No postoperative complications were observed. Among patients who underwent free TRAM flap surgery, 10 (62.5%) received postoperative adjuvant RT, and 13 (81.25%) received adjuvant CT.

All six free DIEP flaps performed were for breast reconstruction. The average patient was 50.1 years, and the mean hospitalization duration was eight days. Mesh was not used during the donor site closure for any DIEP flap patients. Complications included early postoperative microvascular complications necessitating venous re-anastomosis (16.66%) and late-term donor site complications, such as umbilical hernia (16.66%). Three patients (50%) received RT postoperatively, and five (83.3%) received CT.

All VRAM flaps were performed for non-breast reconstruction purposes, with 3 for head and neck, 2 for extremity, and 1 for anterior thoracic wall reconstruction. The mean patient age during surgery was 48.1 years, and the mean hospitalization duration was 28.5 days. Mesh was used during closure of the donor site in 4 patients (66.66%) and not in 2 patients (33.33%). Flap site complications were observed in 2 patients (33.33%). One patient developed scalp dehiscence following reconstruction with a free VRAM flap, treated with a scalp rotation flap. Another patient experienced postoperative venous thrombosis and microcirculatory failure, leading to flap loss despite revision attempts. Four patients (66.66%) received postoperative chemo-radiotherapy.

Complication rates among different flap types revealed that free TRAM flaps had the lowest complication rates (0%), with all other types sharing a similar rate of no complications (66.66%). Details of flap types and complication rates are provided in Table 2.

The correlation between complication rates and mesh use during donor site closure and the administration of postoperative adjuvant RT and CT treatments was analyzed. Details regarding mesh use and complication rates are provided in Table 3. Donor site complication rates were similar regarding mesh use during closure, at 5.88% among patients with mesh used during closure and 5% among those without.

Flap site complication rates were 8.33% among patients who received RT and 23.07% among those who did not. The correlation between complication rates and postoperative RT administration is detailed in Table 4.

The effect of CT on complication rates was investigated. Donor site complication rates were 6.66% among patients who received CT and 0% among those who did not. Flap site complication rates were 10% among patients who received CT and 28.57% among those who did not. The correlation between complication rates and postoperative CT administration is outlined in Table 5.

Table 1. Flap types and patient characteristics

	Patient Number	Age	Flap Site	Laterality	Postoperative Hospital Admission Length (days)	Mesh Use	Postoperative Complications	Adjuvant RT	Adjuvant CT
Pedicled TRAM (n=9)	1	48	Breast	Unilateral	9	None	None	Received	Received
	2	45	Breast	Unilateral	6	Used	None	None	Received
	3	46	Breast	Bilateral	12	Used	Dehiscence at the donor site	Received	Received
	4	56	Breast	Unilateral	11	Used	Dehiscence at flap site, reconstructed with pedicled latissimus dorsi flap	Received	Received
	5	40	Breast	Unilateral	7	None	None	None	Received
	6	38	Breast	Unilateral	7	None	None	Received	Received
	7	45	Breast	Unilateral	11	Used	Thrombosis at vein anastomosis	Received	Received
	8	30	Breast	Unilateral	7	None	None	Received	Received
	9	53	Breast	Unilateral	10	Used	None	Received	None
Free TRAM (n=16)	10	43	Breast	Unilateral	7	Used	None	Received	Received
	11	55	Breast	Unilateral	7	None	None	None	None
	12	32	Breast	Unilateral	8	None	None	Received	Received
	13	49	Breast	Unilateral	8	Used	None	None	Received
	14	43	Breast	Unilateral	7	Used	None	Received	Received
	15	52	Breast	Unilateral	9	None	None	None	None
	16	45	Breast	Unilateral	9	Used	None	Received	Received
	17	46	Breast	Unilateral	11	None	None	Received	Received
	18	37	Breast	Unilateral	9	None	None	Received	Received
	19	39	Arm	Unilateral	26	None	None	None	None
	20	43	Breast	Unilateral	9	Used	None	Received	Received
	21	45	Breast	Unilateral	9	Used	None	None	Received
	22	42	Breast	Unilateral	8	None	None	None	Received
	23	60	Breast	Unilateral	6	Used	None	Received	Received
	24	35	Breast	Unilateral	5	Used	None	Received	Received
	25	50	Breast	Unilateral	8	None	None	Received	Received
VRAM (n=6)	26	40	Scalp	Unilateral	12	Used	Dehiscence at flap site, reconstructed with Scalp flap	None	None
	27	63	Thigh	Unilateral	17	Used	None	Received	Received
	28	56	Leg	Unilateral	24	Used	Flap loss due to thrombosis	None	None
	29	63	Face	Unilateral	16	None	None	Received	Received
	30	20	Skull base	Unilateral	90	None	None	Received	Received
	31	47	Chest Wall	Unilateral	12	Used	None	Received	Received
Free DIEP (n=6)	32	55	Breast	Unilateral	6	None	None	None	None
	33	48	Breast	Unilateral	13	None	Umbilical hernia	Received	Received
	34	47	Breast	Unilateral	6	None	None	Received	Received
	35	51	Breast	Unilateral	10	None	The postoperative venous appearance of a flap, venous thrombosis, treated vein re-anastomosis	None	Received
	36	46	Breast	Unilateral	6	None	None	Received	Received
	37	54	Breast	Unilateral	9	None	None	None	Received

Table 2. Flap types and complication rates

		Complication			Total
		Donor site	Flap Site	None	
Flap Type	Pedicled TRAM (%)	1 (11,11%)	2 (22,22%)	6 (66,66%)	9 (100,00%)
	Free TRAM (%)	0 (0,00%)	0 (0,00%)	16 (100,00%)	16 (100,00%)
	DIEP (%)	1 (16,66%)	1 (16,66%)	4 (66,66%)	6 (100,00%)
	VRAM (%)	0 (0,00%)	2 (33,33%)	4 (66,66%)	6 (100,00%)
Total (%)		2 (5,40%)	5 (13,51%)	30 (81,08%)	37 (100,00%)

Table 3. Mesh use and complication rates

		Complication			Total
		Donor Site	Flap Site	None	
Mesh	Used (%)	1 (5,88%)	4 (23,52%)	12 (70,58%)	17 (100%)
	Not Used (%)	1 (5,00%)	1 (5,00%)	18 (90,00%)	20 (100%)
Total (%)		2 (5,40%)	5 (13,51%)	30 (81,08%)	37 (100%)

Table 4. Adjuvant RT administration and complication rates

		Complication			Total
		Donor Site	Flap Site	None	
Adjuvant RT	Used (%)	2 (8,33%)	2 (8,33%)	20 (83,33%)	24 (100%)
	Not Used (%)	0 (0,00%)	3 (23,07%)	10 (76,92%)	13 (100%)
Total (%)		2 (5,40%)	5 (13,51%)	30 (81,08%)	37 (100%)

Table 5. Adjuvant CT administration and complication rates

		Complication			Total
		Donor Site	Flap Site	None	
Adjuvant CT	Used (%)	2 (6,66%)	3 (10,00%)	25 (83,33%)	30 (100%)
	Not Used (%)	0 (0,00%)	2 (28,57%)	5 (71,42%)	7 (100%)
Total (%)		2 (5,40%)	5 (13,51%)	30 (81,08%)	37 (100%)

DISCUSSION

Abdominal flaps represent a cornerstone in autologous breast reconstruction [17,18], recognized for their superior outcomes in terms of patient satisfaction [19]. In our series, the majority of cases involved breast reconstruction (81.08%). Nearly all non-breast reconstruction procedures (83.33%) comprised VRAM flaps, historically serving as primary agents for perineal and thigh reconstruction [4,20]. VRAM cases in our investigation reveal applications in head and neck reconstruction and the reconstruction of extremities and the chest wall.

Our study's overall incidence of complications stands at 5.40% for donor site complications and 13.51% for flap site complications. Remarkably, 81.08% of patients remained complication-free. Donor site complications primarily manifested as early local wound dehiscence and late-term bulges or hernias. Among these, pedicled TRAM flaps exhibited a donor site complication rate of 11.11%, while the highest incidence, 16.66%, was observed in DIEP flaps. Notably, free-TRAM and VRAM groups displayed no instances of bulges or hernias. Literature suggests that muscle-sparing techniques, such as DIEP or muscle-sparing-TRAM flaps, yield fewer donor site complications due to preserving abdominal wall integrity [21, 22]. However, our findings indicate the lowest donor site complication rates within the free-TRAM and VRAM groups. Nonetheless, bilateral TRAM flap operations, as previously reported, correlated with increased donor site complications [23].

The flap site complication rate of 13.51% aligns with prior investigations [23,24]. Specifically, VRAM flaps exhibited a 33.33% complication rate, followed by p-TRAM (22.22%), DIEP (16.66%),

and free-TRAM (0%) groups. Notably, free TRAM flaps demonstrated the lowest incidence of flap site complications, consistent with earlier studies [25,26]. Past research highlights DIEP flaps' susceptibility to fat necrosis, opposing free-TRAM flaps' resilience [27]. TRAM flaps have historically demonstrated lower flap site complication rates than DIEP flaps [24,28]. Conversely, pedicled flaps appear as the least prone to complications among autologous breast reconstruction options [29,30].

The use of mesh correlates with reduced donor site complications, such as bulging or herniation [31-34]. While prior studies emphasize mesh effectiveness, they suggest that fascial grafts are not essential for safety [35]. Nevertheless, some studies report comparable postoperative bulging or herniation rates between mesh-utilized and non-utilized groups [23]. In our investigation, donor site complication rates were similar between the two groups, at 5.88% in the mesh-utilized and 5% in the non-utilized cohorts.

Breast cancer treatment, apart from surgery, includes chemotherapy (CT) and radiotherapy (RT) based on disease characteristics [36]. CT has been associated with wound dehiscence [37], while post-mastectomy microvascular breast reconstruction under CT regimens is linked to increased complications, particularly fat necrosis [38]. Postoperative RT has also been associated with adverse surgical outcomes [39]. The optimal timing of CT or RT with surgery remains abstract about complication rates [40]. In our series, 64.86% of patients received adjuvant postoperative RT, and 81.08% received postoperative CT. Increased complication rates were expected due to the high CT and RT administration rates. Indeed, our analysis revealed that all patients (n=2) who experienced donor site complications were administered both CT and RT postoperatively, confirming prior evidence linking CT and RT with postoperative complications.

Conversely, our investigation examined the correlation between RT and flap site complications, revealing a complication rate of 8.33% in the RT group versus 23.97% in the RT non-administered group. Similarly, analysis of CT's correlation with complications demonstrated 10% and 28.57% flap site complication rates for the CT-administered and non-administered groups, respectively. However, statistical significance was not established across all cross-tables due to insufficient patient counts.

This study is not without limitations. A retrospective study design limits the depth of analysis, while the small patient cohort limits statistical significance. Future prospective studies with larger patient cohorts are necessary to clarify differences in complication rates among various abdominal flap techniques.

CONCLUSION

Our findings reveal a donor site complication rate of 5.4% and a flap site complication rate of 13.51% across all operations. Free-TRAM and VRAM groups exhibited the lowest donor site complication rates (0%), while the highest rate was observed in the DIEP group (16.66%). The lowest flap site complication rate was observed in the free-TRAM group (0%), contrasting with the highest rate in the VRAM group (33.33%). Mesh utilization did not significantly impact donor site complication rates. Adjuvant postoperative CT and RT administration correlated with increased donor site complications, with all complications observed in patients receiving combined CT and RT.

Author contribution

Study conception and design: GS, GU, HU; data collection: AC, GS, and GU; analysis and interpretation of results: AC, GS, GU, HU; draft manuscript preparation: AC, GS and GU. All authors reviewed the results and approved the final version of the manuscript.

Ethical approval

The study was approved by the institutional review board (Protocol no. 2023/05-04).

Funding

The authors declare that the study received no funding.

Conflict of interest

The authors declare that there is no conflict of interest.

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