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# Postoperative complications in breast reconstruction with deep inferior epigastric perforator flap: Looking for evidence

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**Summary** *Introduction:* This study investigated patient- and surgery-related risk factors of postoperative complications in microvascular breast reconstruction with deep inferior epigastric perforator (DIEP) flaps.
*Methods:* We reviewed the retrospective charts of 212 patients who underwent 250 DIEP flap breast reconstructions between 2018 and 2023. Patient-related factors included demographic characteristics, comorbidities, radiation therapy, and chemotherapy. Surgery-related factors included reconstructive timing and laterality, perforator choice, venous anastomosis technique, and postoperative acetylsalicylic acid (ASA). Early flap complications (first postoperative week) included flap loss, venous congestion, and hematoma. Late flap complications (after the first postoperative week) included wound dehiscence, skin necrosis, fat necrosis, and infection. Donor-site complications (all late) included wound dehiscence, skin necrosis, infection, seroma, and bulging.
*Results:* The overall complication rate was 31.1%, and flap loss was 1.9%. Obesity and diabetes were significantly associated with late flap complications and donor-site complications (dehiscence, infection, fat necrosis, and seroma). Radiation therapy showed trends toward greater total flap loss, take back, and flap skin necrosis. Age, hypertension, smoking, and chemotherapy were not associated with higher complications. Harvesting multiple versus a single perforator was associated with significantly more donor-site complications. There were significantly more early flap complications and a trend toward more bulging with lateral versus medial row perforators. Venous anastomosis with a coupler versus a suture showed significantly

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lower flap complications. Reconstruction timing, laterality, vein number, and ASA use did not impact outcomes.

*Conclusion:* Complications increased by obesity, diabetes, radiation therapy, and the use of multiple and lateral row perforators, as well as sutured venous anastomoses. Conversely, outcomes were not affected by age, hypertension, chemotherapy, reconstructive laterality and timing, vein number, coupler size, or postoperative ASA use.



Approximately 1 in 8 women are expected to develop breast cancer during their lifetime. Breast reconstruction is regarded as an integral part of the therapeutic management of breast cancer because it improves patient quality of life following mastectomy.[1] Reconstruction using autologous tissue flaps has been regarded as an ideal strategy, especially for patients who desire a natural result, have undergone or are expected to undergo radiation therapy, capsular contracture, or require large reconstructive volumes.[1]

The deep inferior epigastric perforator (DIEP) flap has become the autologous flap of choice for breast reconstruction and a routine procedure in many institutions. Although its reliability and attributes are well recognized, complications are not uncommon.[1-3] When they occur, complications lead to increased patient morbidity, higher hospital admissions and revision surgeries, potential delays in adjuvant therapies, and patient and surgeon dissatisfaction.

Several patient-related risk factors of complications following DIEP flap breast reconstruction have been previously investigated.[4-8] Although obesity and smoking have been the most studied, controversies persist regarding their specific complication profiles. Additionally, less evidence exists on other factors, such as diabetes, hypertension, radiation therapy, and chemotherapy.

Surgery-related factors that have been suggested to impact outcomes include perforator choice, venous anastomosis technique, the use of postoperative acetylsalicylic acid (ASA), as well as reconstruction timing and laterality.[9-13] Literature on these surgical factors and their impact on reconstructive outcomes remains insufficiently studied and controversial, resulting in significant variability in surgeon and institutional practices.

To improve autologous reconstruction outcomes for patients with breast cancer, this study aimed to analyze patient- and surgery-related risk factors of complications following DIEP flap breast reconstruction.

## Methods

A retrospective study was conducted on patients who underwent DIEP flap-based breast reconstructions at Lausanne University Hospital between January 2018 and August 2023 by 3 microsurgeons (PDS, W*R*, NK). Institutional review board approval was obtained, and the study was conducted in accordance with the Declaration of Helsinki. Data were collected from a prospectively maintained database and completed with retrospective chart reviews of electronic medical records. Exclusion criteria included patients who underwent other types of autologous reconstructions, including transverse rectus abdominis muscle (TRAM), latissimus dorsi, profunda artery perforator, and transverse upper gracilis flaps, as well as patients with less than 6 months of follow-up.

Patient-related variables included age, body mass index (BMI), obesity (BMI$\geq$30 kg/m$^2$), diabetes, hypertension, tobacco smoking, radiation therapy, and chemotherapy. Smoking was categorized as either non-smoker (never or former) or active smoker at the time of preoperative anesthesiology evaluation. Surgery-related variables included reconstruction laterality (unilateral or bilateral), reconstructive timing (immediate or delayed), perforator number and row, venous anastomosis technique (vein number, suture versus coupler, and coupler size), and use of postoperative ASA (100 mg per day for 1 month).

Early flap complications were defined as occurring within the first postoperative week and included total and partial flap loss, thrombosis, venous congestion, and hematoma. Total flap loss was defined as requiring complete ablation of the flap. Partial flap loss was defined as the loss of part of the flap due to skin and fat necrosis but with a portion of the flap remaining viable, without requiring a second flap procedure. We counted hematomas that required surgical intervention. Takeback was defined by the need for surgical revision during the initial hospital stay.

Late flap complications were defined as occurring after the first postoperative week and included wound dehiscence, skin necrosis, fat necrosis, and infection. Fat necrosis was defined as either acute fat necrosis if it occurs within 1 month postoperatively and was clinically associated with discharge or chronic fat necrosis presenting as an indurated mass and documented through physical examination or imaging after 1 month postoperatively. Only cases of fat necrosis that occurred before secondary fat grafting were counted.

Donor-site complications, which occurred after the first postoperative week, were considered late complications, including wound dehiscence, skin necrosis, infection, seroma, and bulging. Bulging was defined as abdominal weakness or bulging during Valsalva identified during physical examination or imaging. At both the flap and donor site, wound dehiscence was counted if it lasted over a month or required surgical intervention. Cases of wound dehiscence healed within 2–3 weeks with local wound care and were considered minor and excluded from the analysis.

Descriptive statistics were reported using counts and percentages for categorical variables and using means and standard deviation (SD) or medians and range or interquartile range (IQR) for continuous variables. To identify associations between risk factors and complications, bivariate analyses were conducted using Chi-square or the non-parametric Fisher's exact test for categorical variables, and student t-test or the non-parametric Wilcoxon Rank test for continuous variables. *P* values $< 0.05$ were considered statistically significant. Statistical analyses were performed with SAS® (SAS Institute, Cary, NC, USA).

## Results

### Patient characteristics

A total of 212 patients who underwent 250 free DIEP flap breast reconstructions were included in the final analysis. The mean age was 50.3 years ($\pm$8.9), and the mean BMI was 27.5 kg/m$^2$ ($\pm$5.8). The number of patients with a history of active smoking was 16 (7.5%). Non-insulin-resistant diabetes mellitus was diagnosed in 13 (6.1%) patients and hypertension in 29 (13.7%). All diagnosed comorbidities were treated and controlled at the time of surgery, and no patients with diabetes mellitus required insulin. A total of 128 (60.4%) patients received previous postmastectomy radiation therapy, and 157 (74.1%) had a history of chemotherapy. Delayed reconstructions were performed on average 12 months (range 8–18 months) after radiation therapy. The mean follow-up duration was 16.9 ($\pm$9.8) months. Patient demographics are summarized in Table 1.

### Surgical characteristics

Immediate breast reconstruction was performed in 41 (16.4%) DIEP flaps, while delayed reconstruction was performed in 209 (83.6%). A total of 192 (76.8%) flaps were unilateral, while 58 (23.3%) were bilateral. Flaps were raised on single perforators in 134 (53.6%) of cases, while at least 2 perforators were used in 116 (46.4%). Perforators were harvested from the medial row in 164 (65.6%) of cases, from the lateral in 50 (20.0%), and from both rows in 36 (14.4%). Unilateral flaps were most often based on medial row perforators, while bilateral flaps were most often raised on lateral row perforators ($p < 0.001$). Additionally, single perforator flaps were used most often based on medial row perforators, while multiple perforator flaps had higher proportions of lateral row perforators ($p < 0.0001$). The internal mammary artery was used for anastomosis in all cases. A single vein was used in 231 (92.4%) flaps, while multiple veins were used in 19 (7.6%). The venous anastomosis was performed using a coupler in 195 (78.0%) cases and by suture in 55 (22.0%). The most commonly used couplers were 2.5 and 3 mm, with a mean coupler diameter of 2.7 ($\pm$0.5) mm. Indocyanine green (ICG) angiography was used on a case-by-case basis. Postoperative ASA was prescribed in 1456 (58.4%) patients. Surgical characteristics are summarized in Table 2.

### Postoperative complication rates

Postoperative complications occurred in 66 (31.1%) patients. Total flap loss occurred in 4 (1.9%) patients, while partial flap loss occurred in 3 (1.4%). Thrombosis occurred in

**Table 1** Patient characteristics

| Variable | Total patients (n=212) |
|---|---|
| Age, years, mean (SD) | 50.3 (8.9) |
| BMI, kg/m$^2$, mean (SD) | 27.5 (5.8) |
| Obesity, n (%) | 63 (29.7) |
| Smoking status, n (%) | |
| Active | 16 (7.5) |
| Never or former | 196 (92.5) |
| Diabetes mellitus, n (%) | 13 (6.1) |
| Hypertension, n (%) | 29 (13.7) |
| Indication, n (%) | |
| Cancer | 207 (97.6) |
| Prophylactic | 5 (2.4) |
| Neoadjuvant chemotherapy, n (%) | 157 (74.1) |
| Previous radiation therapy, n (%) | 128 (60.4) |
| Length of stay, nights, mean (SD) | 6.9 (3.6) |
| Follow-up, months, mean (SD) | 16.9 (9.8) |

BMI, body mass index; SD, standard deviation.

**Table 2** Surgical characteristics

| Variable | Total flaps (n=250) |
|---|---|
| Reconstruction timing, n (%) | |
| Immediate | 41 (16.4) |
| Delayed | 209 (83.6) |
| Reconstruction laterality, n (%) | |
| Unilateral | 192 (76.8) |
| Bilateral | 58 (23.2) |
| Type of DIEP flap, n (%) | |
| Classic DIEP | 228 (91.2) |
| Lympho-DIEP | 4 (1.6) |
| Bi-pedicled DIEP | 14 (5.6) |
| Bi-pedicled lympho-DIEP | 4 (1.6) |
| Perforator number, n (%) | |
| 1 | 134 (53.6) |
| 2 | 86 (34.4) |
| ≥3 | 30 (12.0) |
| Perforator row, n (%) | |
| Medial | 164 (65.6) |
| Lateral | 50 (20.0) |
| Both | 36 (14.4) |
| Number of veins, n (%) | |
| 1 | 231 (92.4) |
| 2 | 19 (7.6) |
| Venous anastomosis, n (%) | |
| Suture | 55 (22.0) |
| Coupler | 195 (78.0) |
| Coupler size, mm, mean (SD) | 2.7 (0.5) |
| Postoperative ASA, n (%) | 146 (58.4) |

ASA, acetylsalicylic acid; DIEP, deep inferior epigastric perforator; SD, standard deviation.

5 (2.4%) patients, which led to postoperative takeback in 3 (1.4%) and was salvaged intraoperatively in 2 (0.9%). Venous congestion was seen in 12 (5.7%) patients, with 9 (4.2%) requiring takeback. Five (2.4%) of these flaps were salvaged, while 2 (0.9%) underwent partial flap failure and 2 (0.9%) total flap failure. In 3 (1.4%) patients, venous congestion did not require takeback and evolved favorably with conservative leech therapy. There were 9 (4.2%) cases of hematoma, all of which were taken back.

Flap wound dehiscence affected 8 (3.8%) patients, including 1 (0.5%) who required a vacuum-assisted closure (VAC). Fat necrosis affected 16 (7.5%) patients and consisted of acute fat necrosis in 4 (1.9%) cases (treated by either office or intraoperative drainage), and chronic fat necrosis was seen in 8 (3.8%) (with 2 [0.9%] patients requiring surgical excision). Localized flap skin necrosis occurred in 7 (3.3%) patients, and among immediate breast reconstructions, skin necrosis of the mastectomy flap occurred in 1 (2.6%). Treatment for these patients consisted of office debridement and wound care for the majority (n=5, 62.5%). For 2 (25.0%) cases, operative debridement was necessary with subsequent primary closure or skin grafting. There were 4 (1.9%) patients who developed a flap infection, of which 3 (1.4%) required surgical treatment, while 1 (0.5%) case of cellulitis resolved favorably with antibiotics.

Abdominal wound dehiscence occurred in 10 (4.7%) patients. All were treated with conservative dressing protocols, but 3 (1.4%) required reoperation with VAC and subsequent skin grafting. Skin necrosis was seen in 5 (2.4%), and all were treated with office debridement and wound care. Seroma was the most common donor-site complication and occurred in 14 (6.6%) patients. All cases were managed conservatively except for 1 (0.5%) who necessitated drainage. There were 5 (2.4%) patients who developed an infection, of whom 3 (1.4%) were managed with antibiotics and 1 (0.5%) required surgical treatment. Bulging occurred in 10 (4.7%) patients, with 1 (0.5%) subsequently undergoing mesh repair.

Twenty-six (12.3%) patients experienced medical complications, the most common of which was anemia with a hemoglobin concentration of $<100$ g/L. Other medical complications that occurred during hospitalization included pulmonary embolism, urinary tract infection, pneumonia, pneumothorax, and neuropraxia. An overview of complication rates is presented in Table 3.

**Table 3** Complication rates

| Complication | Total patients (n=212) |
|---|---|
| Total complications, n (%) | 66 (31.1) |
| Early flap complication, n (%) | 18 (8.5) |
| Take back | 17 (8.0) |
| Total flap loss | 4 (1.9) |
| Partial flap loss | 3 (1.4) |
| Thrombosis | 5 (2.4) |
| Venous congestion | 12 (5.7) |
| Hematoma | 9 (4.2) |
| Late flap complication, n (%) | 40 (18.9) |
| Skin necrosis | 8 (3.8) |
| Flap skin necrosis | 7 (3.3) |
| Mastectomy flap necrosis | 1 (0.5) |
| Fat necrosis | 16 (7.5) |
| Wound dehiscence | 8 (3.8) |
| Infection | 4 (1.9) |
| Donor-site complication, n (%) | 37 (17.5) |
| Skin necrosis | 5 (2.4) |
| Wound dehiscence | 10 (4.7) |
| Seroma | 14 (6.6) |
| Infection | 5 (2.4) |
| Abdominal bulging | 10 (4.7) |

## Patient-related risk factors

Obese patients had significantly higher rates of flap and donor-site wound dehiscence, flap and donor-site infection, flap fat necrosis, and length of stay (LOS) ($p<0.05$). Diabetics had significantly higher rates of flap and donor-site wound dehiscence, donor-site infection, and donor-site seroma ($p<0.05$). There were trends toward higher rates of total flap loss, takebacks, and flap skin necrosis with previous radiation therapy. Patients who underwent previous radiation therapy had significantly longer LOS ($p<0.05$). Patients with a history of receiving chemotherapy had significantly lower rates of flap fat necrosis and donor-site seroma ($p<0.05$). Age, hypertension, and smoking were not significantly associated with any of the analyzed complications ($p>0.05$). However, the mean LOS in patients aged 60 years and over was significantly higher than in patients aged under 60 years ($p<0.05$). Complication rates by patient-related factors are presented in Table 4.

## Surgery-related risk factors

There were no significant differences in complication rates between immediate and delayed reconstructions, as well as between unilateral and bilateral reconstructions ($p>0.05$). However, immediate reconstructions had significantly longer LOS than delayed reconstructions ($p<0.05$). Lympho-DIEPs, bipedicled-DIEPs, and lympho-bipedicled-DIEPs all had similar complication profiles to classic DIEP flaps ($p>0.05$).

Flaps based on multiple perforators had significantly higher rates of donor-site complications compared with flaps based on single perforators ($p<0.05$) and had trends toward higher rates of partial flap necrosis and fat necrosis (p=0.06). Flaps based on lateral row perforators were significantly more likely to have early flap complications compared with flaps based on medial row perforators ($p<0.05$) and a trend toward higher rates of any donor-site complications and abdominal bulging (p=0.07).

Flaps with sutured venous anastomoses had trends toward higher rates of venous congestion compared with flaps with coupler anastomosis (p=0.09), as well as significantly higher rates of late flap complications, including fat necrosis ($p<0.05$). For flaps based on a single vein, coupler size was not associated with complication rates ($p>0.05$). The number of veins anastomosed for flap drainage and the use of postoperative ASA use were not associated with flap complications ($p<0.05$). Complication rates by surgery-related factors are presented in Table 5.

**Table 4** Patient-related factors and postoperative complications

| Complication | Age, years (%) | | | Obesity (%) | | | Hypertension (%) | | | Smoking (%) | | | Diabetes (%) | | | Neoadjuvant CT (%) | | | Previous RT (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | < 60 | ≥60 | *p* | No | Yes | *p* | No | Yes | *p* | No | Yes | *p* | No | Yes | *p* | No | Yes | *p* | No | Yes | *p* |
| Early flap complication | 7.4 | 10.5 | 0.516 | 8.2 | 6.3 | 0.598 | 7.9 | 5.6 | 0.617 | 7.8 | 5.3 | 0.689 | 8.1 | 0.0 | 0.252 | 4.8 | 8.5 | 0.344 | 4.7 | 9.8 | 0.131 |
| Total flap loss | 1.5 | 2.6 | 0.613 | 2.4 | 0.0 | 0.169 | 1.9 | 0.0 | 0.408 | 1.3 | 5.3 | 0.186 | 1.7 | 0.0 | 0.611 | 0.0 | 2.1 | 0.247 | 0.0 | 2.8 | 0.081 |
| Partial flap loss | 1.0 | 2.6 | 0.403 | 1.8 | 0.0 | 0.235 | 1.4 | 0.0 | 0.475 | 1.3 | 0.0 | 0.617 | 1.3 | 0.0 | 0.660 | 1.6 | 1.1 | 0.731 | 0.0 | 2.1 | 0.132 |
| Venous congestion | 4.5 | 7.9 | 0.372 | 5.9 | 2.5 | 0.251 | 5.6 | 0.0 | 0.145 | 4.8 | 5.3 | 0.922 | 5.1 | 0.0 | 0.370 | 4.8 | 4.5 | 0.987 | 2.8 | 6.3 | 0.202 |
| Hematoma | 3.5 | 2.6 | 0.793 | 3.5 | 2.5 | 0.678 | 2.8 | 5.6 | 0.385 | 3.5 | 0.0 | 0.410 | 3.4 | 0.0 | 0.468 | 3.2 | 3.2 | 0.989 | 1.9 | 4.2 | 0.301 |
| Take back | 6.4 | 10.5 | 0.367 | 7.7 | 5.1 | 0.452 | 7.0 | 5.6 | 0.749 | 6.9 | 5.3 | 0.792 | 7.2 | 0.0 | 0.281 | 3.2 | 8.0 | 0.197 | 3.7 | 9.1 | 0.096 |
| Late flap complication | 17.3 | 10.5 | 0.297 | 10.6 | 26.6 | **0.001*** | 16.4 | 11.1 | 0.422 | 15.6 | 15.8 | 0.981 | 14.5 | 33.3 | 0.051 | 22.6 | 13.3 | 0.081 | 12.2 | 18.2 | 0.193 |
| Skin necrosis | 4.0 | 0.0 | 0.212 | 2.4 | 5.1 | 0.259 | 3.7 | 0.0 | 0.238 | 3.5 | 0.0 | 0.410 | 3.0 | 6.7 | 0.431 | 3.2 | 3.2 | 0.989 | 0.9 | 4.9 | 0.083 |
| Wound dehiscence | 3.0 | 2.6 | 0.909 | 0.6 | 7.6 | **0.002*** | 2.3 | 5.6 | 0.279 | 3.0 | 0.0 | 0.442 | 1.3 | 26.7 | **< 0.00*** | 1.6 | 3.2 | 0.514 | 0.9 | 4.2 | 0.122 |
| Fat necrosis | 7.4 | 2.6 | 0.277 | 3.5 | 12.7 | **0.006*** | 7.0 | 2.8 | 0.337 | 6.5 | 5.3 | 0.833 | 6.4 | 6.7 | 0.965 | 14.5 | 3.7 | **0.003*** | 5.6 | 7.0 | 0.658 |
| Seroma | 1.5 | 0.0 | 0.450 | 1.8 | 0.0 | 0.235 | 1.4 | 0.0 | 0.475 | 0.9 | 5.3 | 0.212 | 1.3 | 0.0 | 0.660 | 1.6 | 1.1 | 0.731 | 1.9 | 0.7 | 0.401 |
| Infection | 2.0 | 0.0 | 0.382 | 0.0 | 5.1 | **0.003*** | 1.9 | 0.0 | 0.408 | 1.7 | 0.0 | 0.563 | 1.7 | 0.0 | 0.611 | 0.0 | 2.1 | 0.247 | 0.9 | 2.1 | 0.468 |
| Donor-site complication | 16.8 | 18.4 | 0.811 | 13.5 | 22.8 | **0.067** | 16.4 | 16.7 | 0.963 | 16.9 | 10.5 | 0.472 | 13.2 | 66.7 | **< 0.00*** | 21.0 | 14.9 | 0.263 | 13.1 | 18.9 | 0.221 |
| Skin necrosis | 0.0 | 5.6 | 0.697 | 2.4 | 1.3 | 0.569 | 2.3 | 0.0 | 0.354 | 2.2 | 0.0 | 0.517 | 1.7 | 6.7 | 0.183 | 3.2 | 1.6 | 0.427 | 1.9 | 2.1 | 0.898 |
| Wound dehiscence | 4.5 | 2.6 | 0.606 | 0.6 | 11.4 | **< 0.00*** | 3.7 | 5.6 | 0.607 | 3.9 | 5.3 | 0.770 | 3.0 | 20.0 | **0.001*** | 3.2 | 4.3 | 0.720 | 1.0 | 6.3 | 0.095 |
| Seroma | 6.4 | 7.9 | 0.741 | 6.5 | 6.3 | 0.966 | 5.6 | 11.1 | 0.212 | 6.5 | 5.3 | 0.833 | 5.1 | 26.7 | **0.001*** | 12.9 | 4.3 | **0.016*** | 6.5 | 6.3 | 0.937 |
| Infection | 2.5 | 0.0 | 0.327 | 0.6 | 5.1 | **0.019*** | 2.3 | 0.0 | 0.354 | 2.2 | 0.0 | 0.517 | 1.3 | 13.3 | **0.001*** | 1.6 | 2.1 | 0.802 | 0.9 | 2.8 | 0.298 |
| Bulging | 5.0 | 5.3 | 0.935 | 5.9 | 2.5 | 0.251 | 5.1 | 2.8 | 0.540 | 4.8 | 5.3 | 0.922 | 5.1 | 0.0 | 0.370 | 8.1 | 3.7 | 0.166 | 6.5 | 3.5 | 0.265 |

CT, chemotherapy; RT, radiation therapy.

* Statistically significant ($p < 0.05$).

**Table 5** Surgery-related factors and postoperative complications

| Complication | Bilateral reconstruction (%) | | | Immediate reconstruction (%) | | | Perforator number (%) | | | Perforator row (%) | | | Vein number (%) | | | Venous anastomosis (%) | | | Coupler Size (%) | | | Postoperative ASA (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No | Yes | *p* | No | Yes | *p* | 1 | ≥2 | *p* | Med | Lat | *p* | 1 | 2 | *p* | Coupler | Suture | *p* | < 2.5 | ≥2.5 | *p* | No | Yes | *p* |
| Early flap complication | 8.7 | 5.4 | 0.423 | 7.2 | 9.8 | 0.569 | 5.2 | 10.3 | 0.128 | 4.3 | 12.0 | **0.045*** | 8.2 | 0.0 | 0.616 | 6.2 | 12.7 | 0.263 | 7.1 | 6.5 | 0.897 | 4.9 | 9.6 | 0.172 |
| Total flap loss | 2.2 | 0.0 | 0.267 | 1.9 | 0.0 | 0.372 | 1.5 | 1.7 | 0.884 | 1.2 | 2.0 | 0.681 | 1.7 | 0.0 | 0.563 | 1.0 | 3.6 | 0.175 | 0.0 | 1.4 | 0.523 | 0.0 | 2.7 | 0.092 |
| Partial flap loss | 1.6 | 0.0 | 0.338 | 1.0 | 2.4 | 0.426 | 0.0 | 2.3 | 0.061 | 0.6 | 0.0 | 0.580 | 1.3 | 0.0 | 0.617 | 1.0 | 1.8 | 0.637 | 0.0 | 1.4 | 0.523 | 0.0 | 2.1 | 0.145 |
| Thrombosis | 1.6 | 3.6 | 0.370 | 5.6 | 1.4 | 0.302 | 0.8 | 3.4 | 0.128 | 2.4 | 2.2 | 0.857 | 2.2 | 0.0 | 0.157 | 2.3 | 3.6 | 0.623 | 3.6 | 1.4 | 0.438 | 0.0 | 3.4 | 0.059 |
| Venous congestion | 5.4 | 3.6 | 0.580 | 4.3 | 7.3 | 0.410 | 3.0 | 6.9 | 0.149 | 3.1 | 6.0 | 0.336 | 5.2 | 0.0 | 0.309 | 3.6 | 9.1 | 0.094 | 7.1 | 2.9 | 0.269 | 2.0 | 6.9 | 0.078 |
| Hematoma | 3.8 | 1.8 | 0.465 | 4.9 | 2.9 | 0.504 | 3.7 | 2.6 | 0.608 | 2.8 | 7.0 | 0.063 | 3.5 | 0.0 | 0.410 | 3.6 | 1.8 | 0.506 | 3.6 | 4.3 | 0.858 | 3.9 | 2.7 | 0.604 |
| Take back | 7.6 | 5.4 | 0.571 | 5.7 | 12.2 | 0.133 | 5.2 | 8.6 | 0.287 | 4.9 | 10.0 | 0.184 | 7.4 | 0.0 | 0.221 | 5.7 | 10.9 | 0.299 | 7.1 | 6.5 | 0.897 | 3.9 | 8.9 | 0.127 |
| Late flap complication | 17.8 | 10.7 | 0.205 | 14.4 | 22.0 | 0.220 | 12.7 | 19.0 | 0.172 | 12.2 | 18.0 | 0.293 | 15.2 | 21.1 | 0.731 | 14.1 | 25.5 | 0.052 | 7.1 | 13.7 | 0.342 | 7.8 | 12.6 | 0.061 |
| Skin necrosis | 2.7 | 5.4 | 0.331 | 2.4 | 7.3 | 0.101 | 3.7 | 2.6 | 0.608 | 2.4 | 6.0 | 0.215 | 3.5 | 0.0 | 0.410 | 3.1 | 3.6 | 0.840 | 0.0 | 3.6 | 0.308 | 2.9 | 2.7 | 0.925 |
| Fat necrosis | 2.7 | 3.6 | 0.735 | 9.8 | 5.7 | 0.337 | 3.7 | 9.4 | 0.064 | 4.9 | 4.0 | 0.797 | 6.9 | 0.0 | 0.236 | 3.8 | 16.4 | **0.003*** | 0.0 | 5.0 | 0.225 | 2.9 | 8.9 | 0.060 |
| Wound dehiscence | 8.1 | 1.8 | 0.096 | 2.9 | 2.4 | 0.878 | 3.7 | 1.7 | 0.337 | 3.7 | 0.0 | 0.170 | 2.2 | 10.5 | 0.092 | 3.8 | 0.0 | 0.356 | 3.6 | 3.6 | 0.995 | 2.9 | 2.7 | 0.925 |
| Seroma | 1.1 | 1.8 | 0.677 | 0.5 | 4.9 | 0.071 | 1.5 | 0.9 | 0.648 | 1.2 | 2.0 | 0.681 | 0.9 | 5.3 | 0.212 | 1.6 | 0.0 | 0.354 | 0.0 | 1.4 | 0.523 | 2.0 | 0.7 | 0.366 |
| Infection | 1.6 | 1.8 | 0.933 | 1.0 | 4.9 | 0.067 | 3.0 | 0.0 | 0.061 | 2.4 | 0.0 | 0.265 | 1.7 | 0.0 | 0.563 | 2.1 | 0.0 | 0.579 | 0.0 | 2.2 | 0.433 | 1.0 | 2.1 | 0.646 |
| Donor-site complication | 18.9 | 10.7 | 0.152 | 17.2 | 12.2 | 0.427 | 11.9 | 21.6 | **0.041*** | 13.4 | 24.0 | 0.073 | 16.0 | 21.1 | 0.569 | 16.6 | 29.1 | 0.059 | 7.1 | 14.4 | 0.301 | 12.8 | 19.2 | 0.180 |
| Skin necrosis | 2.7 | 0.0 | 0.214 | 1.9 | 2.4 | 0.826 | 1.5 | 2.6 | 0.538 | 1.2 | 2.0 | 0.681 | 2.2 | 0.0 | 0.517 | 1.6 | 3.6 | 0.329 | 0.0 | 2.2 | 0.434 | 2.0 | 2.1 | 0.959 |
| Wound dehiscence | 5.4 | 0.0 | 0.076 | 4.8 | 0.0 | 0.153 | 3.0 | 5.2 | 0.379 | 3.1 | 4.0 | 0.741 | 3.5 | 10.5 | 0.131 | 3.2 | 7.3 | 0.243 | 3.6 | 2.9 | 0.844 | 2.9 | 4.8 | 0.465 |
| Seroma | 7.8 | 3.6 | 0.293 | 6.7 | 4.9 | 0.663 | 3.7 | 9.5 | 0.064 | 6.1 | 10.0 | 0.344 | 5.6 | 15.8 | 0.082 | 6.7 | 5.5 | 0.739 | 3.6 | 7.9 | 0.417 | 5.9 | 6.9 | 0.760 |
| Infection | 2.7 | 0.0 | 0.214 | 1.9 | 2.4 | 0.826 | 3.0 | 0.9 | 0.232 | 2.4 | 2.0 | 0.857 | 2.2 | 0.0 | 0.517 | 1.6 | 3.6 | 0.323 | 0.0 | 2.2 | 0.433 | 2.0 | 2.1 | 0.959 |
| Bulging | 5.4 | 3.4 | 0.580 | 5.7 | 0.0 | 0.116 | 3.7 | 6.0 | 0.396 | 3.7 | 10.0 | 0.076 | 4.8 | 5.3 | 1.000 | 2.9 | 10.9 | 0.051 | 3.6 | 2.9 | 0.844 | 3.9 | 5.5 | 0.574 |

ASA, acetylsalicylic acid.

* Statistically significant ($p < 0.05$).

## Discussion

This study analyzed patient- and surgery-related risk factors associated with postoperative complications following breast reconstruction with DIEP flap.

### Obesity and diabetes mellitus

Obesity and diabetes were associated with higher rates of late flap complications and donor-site complications, including wound dehiscence, infection, fat necrosis, and seroma. The increased risk of these complications has been previously shown by most authors and is likely due to compromised perfusion, wound healing, and immunity; greater intra-abdominal pressure; longer scars; underlying fat necrosis; as well as increased perfusion demands when larger tissue volumes are mobilized.[4,6,14-16] The increased rate of late complications in these patients may be preventable through weight loss counseling and diabetic control, as well as appropriate perforator choice, the avoidance of supra-dimensioned flaps, and prophylactic excision of high-risk flap zones to ensure adequate flap perfusion. Further, in contrast to TRAM flaps, obesity and diabetes do not seem to be risk factors for abdominal bulging, suggesting that abdominal weakness following DIEP flaps may be more related to fascia quality, surgical dissection technique, and perforator choice.[4,14,15,17] In line with our results, there seems to be a consensus that neither obesity nor diabetes predisposes to early flap complications, such as flap loss and takebacks, and therefore should not contraindicate surgery on this basis.[3,5,7,17-19] Only a few authors have noted higher rates of takebacks and venous congestion.[4,18]

### Radiation therapy

The trend toward increased rates of early flap complications in radiated recipient sites found in our study is similar to previous findings reporting greater rates of flap loss.[4,20] Radiation therapy causes tissue and vessel fibrosis, edema, and vasculitis, which may complicate the dissection of the internal mammary vessels. While several studies have failed to find higher rates of flap complications with radiation, this is likely attributed to the inherently low incidence of flap loss, requiring large sample sizes.[3,5,8,18,19] In line with previous results, radiation therapy did not significantly affect late flap complications such as fat necrosis.[7,19,20]

### Smoking

Despite the known negative effects of smoking, we did not find higher complication rates in smokers, similar to several previous studies.[1,4,5,7,8] However, there seems to remain significant controversy, since many reports have found higher rates of wound dehiscence, fat necrosis, and skin necrosis in smokers.[4,9,17-19] It is possible that significance was not reached in our study due to the low proportions of active smokers (7.5%), making it difficult to identify strong correlations.

### Age

Older age was not associated with higher rates of early or late flap and donor-site complications, in line with most of the literature.[7,17-19] Only one study showed that being an elderly woman was a risk factor for total DIEP flap loss and wound dehiscence, adding minimal controversy in the literature.[21]

### Hypertension

Our results did not suggest hypertension to be a significant risk factor, in line with most of the existing literature.[7,9,19,20] To our knowledge, no articles have reported on hematoma rates in patients with hypertension undergoing breast reconstruction with DIEP flap. The detrimental effects of hypertension may be more apparent in untreated hypertension or in the context of coexisting metabolic syndrome.

### Chemotherapy

Chemotherapy was not an apparent risk factor, in line with previous reports that have found no significant increases in flap and donor-site complication rates.[2,4,18] Only a few articles reported higher rates of fat necrosis and wound healing problems.[7] Interestingly, our results showed significantly lower rates of fat necrosis and seroma, which have also been reported by others.[9] It is unclear why this association was found, but when controlling for possible confounding factors, patients with chemotherapy had lower BMIs, less smoking history, and less immediate reconstructions, which together could have had an accumulative effect in decreasing complication rates. Since our findings showed that chemotherapy was not as significant a risk factor as radiation therapy, in our opinion, immediate reconstructions following chemotherapy may be performed without any concern.

### Reconstruction timing

Immediate and delayed reconstructions had similar complication rates, in line with most of the literature, including a recent meta-analysis.[2,19,22-24] However, some studies have found higher rates of hematomas and takebacks in immediate reconstructions.[23,24] In our opinion, the risk of hematoma with immediate reconstruction may be reduced with surgeon experience.

### Reconstruction laterality

Although bilateral DIEP reconstructions involve greater dissection, operative times, and possibly restrained perforator choice, we found similar rates of complications between bilateral and unilateral reconstructions, in line with most of the existing literature.[5,19,25] Nevertheless, some studies have found higher rates of flap loss, takebacks, fat necrosis, and bulging in bilateral reconstructions.[1,17] In contrast, others have found higher rates of fat necrosis in unilateral flaps, possibly due to the tendency to

harvest larger volumes which may reduce flap perfusion especially if lateral row perforators are chosen.[6,25] Higher rates of bulging have also been reported with unilateral flaps, possibly due to increased dissection concentrated on one side of the abdomen, especially if multiple perforators are used.[26,27]

### Perforator selection

Perforator selection has been notably debated among microsurgeons. We found that lateral perforators had higher rates of flap complications compared with medial perforators. The effect of the perforator row on flap complications has shown significant controversy.[9-12,19] However, anatomic studies have shown larger perforator calibers and greater perfusion territories with medial row perforators.[28,29] Additionally, the use of multiple perforators also tended to result in higher rates of flap complications. While several authors, including a recent clinical study investigating flap perfusion using ICG fluorescence angiography, have not found significant differences in flap complication rates with varying numbers of perforators,[9,10,13,19,30,31] others have found increased complications with fewer perforators.[11,12,16,22] The authors believe that a single dominant medial perforator can provide sufficient flap perfusion to well-designed flaps. Increased flap complications with medial perforators compared with lateral row perforators seen in previous literature are likely due to the design of oversized flaps instead of choosing stacked or bipedicled flaps. A single medial perforator may also lower the risk of donor-site morbidity, including bulging, by reducing dissection and the risk of severing the rectus abdominis muscle motor nerves.[9,10,26] Nevertheless, perforator selection follows a complex process that includes a combination of number, row, caliber, length, intramuscular course, and needed flap volume.

### Venous anastomosis

Increased flap complications with sutured venous anastomoses compared with couplers are likely due to increased thrombogenicity, their technique-dependent success, and longer ischemia as well as operative times. Other studies have also found increased flap loss, takebacks, and venous thrombosis with sutured anastomosis,[32,33] although some have failed to find significant differences.[34,35] Additionally, although we did not find that coupler size influenced complication rates, the minimal literature that does exist is controversial, with authors suggesting either no difference, higher complications, or lower complications with different coupler sizes.[5,33,36] The learning curve associated with coupler use as well as other technical factors, such as pedicle positioning to avoid twisting, may explain current controversies. Further, although previous studies have found less venous congestion and takebacks with multiple veins, the number of veins anastomosed did not influence outcomes in our study.[5,37,38] The authors of this study believe that the prophylactic addition of a second vein is usually unnecessary if no injury to the pedicle has occurred. However, the addition of a second vein may be useful in the case of superficial inferior epigastric vein-dominant flaps.

### Postoperative ASA use

In line with previous studies, ASA use did not significantly impact reconstructive outcomes.[39,40] The theorized benefit of reducing thrombotic complications with ASA use is based on previous animal studies, and no clinical reports have recommended its use in addition to postoperative prophylactic anticoagulation therapy following microsurgical breast reconstruction. Consequently, the use of postoperative ASA has been discontinued in the authors' institution.

### Limitations

Our study had limitations, notably its retrospective nature, sample size, and multiple operating surgeons. Our analysis also lacked details regarding other factors that may influence complication rates, including hemoglobin A1c levels, smoking pack years, radiation therapy, and chemotherapy regimens, as well as flap weight, vessel caliber, and pedicle length. Similarly, the timing and impact of contralateral symmetrization might also have played a role in our series.

## Conclusions

This study analyzed patient- and surgery-related risk factors for postoperative complications following breast reconstruction with DIEP flaps. We found that obesity and diabetes were predisposed to late flap and donor-site complications, while radiation therapy trended toward higher early flap complications. Further, harvesting multiple and lateral perforators was predisposed to increased donor-site morbidity and worse flap perfusion compared with single and medial perforators, and venous anastomosis with suture was associated with higher flap complications compared with the use of a coupler. In contrast, age, hypertension, chemotherapy, reconstructive laterality and timing, vein number, coupler size, and the use of postoperative ASA did not impact outcomes.

## Institutional Review Board

Institutional Review Board approval (protocol 2022-01630).

## Conflicts of Interest

Pietro G. di Summa is a Deputy Editor for JPRAS and was not involved in the editorial review or the decision to publish this article. All remaining authors declare no conflict of interest.

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