Predicting and Managing Donor-Site Wound Complications in Abdominally Based Free Flap Breast Reconstruction: Improved Outcomes with Early Reoperative Closure

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Background: The purpose of this study was to (1) determine risk factors predictive of delayed abdominal healing; (2) determine characteristics that perpetuate progression to chronic abdominal wounds and describe the resultant morbidity; and (3) identify outcomes and cost following two treatment strategies—conservative wound care and early reoperative primary closure.
Methods: Patients were identified from a database of abdominally based free flaps performed from January of 2005 through July of 2012.
Results: One thousand two hundred eighteen abdominal donor sites were reviewed, and 167 cases (13.7 percent) of delayed abdominal wound healing were identified. Obesity ($p < 0.0001$), smoking ($p = 0.043$), bilateral reconstruction ($p = 0.006$), preoperative chemotherapy ($p = 0.006$), and abdominal mesh ($p = 0.028$) were independently associated with delayed healing. Initiation of chemotherapy ($p < 0.0001$), wet-to-dry wound care ($p = 0.001$), negative-pressure wound therapy ($p = 0.002$), and flap type ($p = 0.047$) were predictive of chronic wounds, and such wounds generated higher rates of hospital readmission ($p = 0.009$), mesh complications ($p < 0.001$), and hernia/bulge ($p = 0.006$). Patients who underwent delayed primary wound closure were more likely to have a well-healed abdomen within 1 month (90.9 percent versus 24.2 percent; $p < 0.0001$), resulting in lower cost, fewer hospital readmissions, lower rates of scar revision, and lower rates of mesh complications/hernia/bulge.
Conclusions: Chronic abdominal wounds were associated with abdominal wall sequelae, including hernia. Early reoperative primary wound closure has been successfully and selectively implemented, resulting in improved patient outcomes. (*Plast. Reconstr. Surg.* 135: 14, 2015.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Risk, III.

The abdominal donor site is routinely used in the harvest of tissue for free flap breast reconstruction. Over two decades of outcomes studies have repeatedly demonstrated that use of the abdominal donor site is a safe and reproducible technique with which to reconstruct the breast mound.[1–8] Flap harvest ideally concludes with primary closure of the donor site under minimal tension, ultimately providing an aesthetically pleasing abdominal contour. Despite the reliability and aesthetic benefit of the abdominal wall donor site, there can be an understated component of postoperative delayed healing (Figs. 1 and 2).

Risk factors for developing abdominal wound complications following free flap breast reconstruction have been delineated. Obesity has been often cited, along with other comorbidities typically associated with poor wound healing.[9–16] Routine delayed healing can, however, progress to chronic abdominal wounds that persist for greater than 3 to 6 months after the initial reconstruction. In our experience, chronic abdominal wounds

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Received for publication March 14, 2014; accepted June 6, 2014.
Presented at The Aesthetic Meeting 2014, in San Francisco, California, April 24 through 29, 2014.
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DOI: 10.1097/PRS.0000000000000805

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

result in added cost, more office visits, greater resource use, patient dissatisfaction, poor donor-site appearance, and more frequent abdominal wall morbidity (e.g., mesh complications and hernia). Long-standing abdominal wounds are thus tremendously problematic and, one can argue, result in an overall failure of reconstruction. To date, there is a paucity of evidence-based literature on the treatment of abdominal delayed healing and the long-term sequelae of subsequent mismanagement. Similarly, there are no outcomes-based operative strategies for avoiding such long-term failure.

In this study, we perform a comprehensive outcomes-based assessment of delayed healing of the abdominal donor-site following free flap breast reconstruction and propose an evidence-based algorithm for treatment. Therefore, the purpose of this study is three-fold: (1) determine risk factors predictive of delayed abdominal healing; (2) determine characteristics that perpetuate progression to chronic abdominal wounds and describe the resultant morbidity; and (3) identify outcomes and cost following two treatment strategies—conservative wound care and early reoperative primary closure.

PATIENTS AND METHODS

A retrospective review of patient electronic medical records was performed on all patients undergoing abdominally based free flap breast reconstruction (i.e., transverse rectus abdominis myocutaneous, deep inferior epigastric perforator, and superficial inferior epigastric perforator flaps) at the Division of Plastic Surgery, University of Pennsylvania, from January of 2005 to July of 2012. Institutional review board approval was granted for this study. Hospital records detailing the preoperative workup, intraoperative care, and immediate postoperative course were used. Patient characteristics, comorbidities, and potential perioperative risk factors were identified for all patients. These variables included age, hypertension, coronary artery disease, peripheral vascular disease, dyslipidemia, chronic obstructive pulmonary disease, diabetes, smoking history, active smoking history, preoperative chemotherapy, reconstruction laterality, and obesity (body mass index >30 kg/m^2). Obesity was further stratified by the World Health Organization definition of obesity, classified as follows: nonobese (body mass index less than 30 kg/m^2), class I obese (body mass index, 30.0 to 34.9 kg/m^2), class II obese (body mass index, 34.9 to 39.9 kg/m^2), and class III obese (body mass index ≥40 kg/m^2).

Routine postoperative office visits included a detailed physical examination that was well-documented among all attending surgeons. According to institutional protocol, patients were instructed to return for outpatient follow-up at 1 week, 2 weeks, 6 weeks, 3 months, and 6 months postoperatively. There remains variability in the frequency and number of office visits among patients and attending surgeons. Patients with open abdominal wounds returned to the office at more frequent intervals than the above-mentioned norms and were typically instructed to return to the office every 2 weeks until a well-healed abdomen was identified.

Fig. 1. Postoperative patient demonstrating full-thickness central wound dehiscence and mastectomy skin flap necrosis that share similar risk factors.

Fig. 2. Postoperative abdominal wound dehiscence following free flap breast reconstruction.

Delayed healing was defined as an open abdominal wound that persisted for greater than 30 days postoperatively. The primary endpoint, complete healing, denoted a clean, dry, and intact wound without any clinically appreciable open areas wider than 0.5 cm. Reoperative wound closure treatment (technique described below) was defined as any open abdominal wound that was electively closed primarily within 4 months of the initial reconstruction. In comparing treatment modalities, delayed primary wound closure was compared to patients who received extensive conservative wound measures including both wet-to-dry dressing changes and/or negative-pressure wound therapy. Endpoints of interest included closure within 1 month of treatment modality; closure within 6 months of initial surgery; and rates of scar revision, mesh extrusion/removal, hernia/bulge, emergency room visitation, hospital readmission, and overall failure of wound treatment. Failure of treatment was defined as the need for reoperative surgery and/or an open wound that persisted 6 months beyond the initial reconstruction. Cost data were obtained following a query of the charges for inpatient admissions, emergency room evaluation, inpatient surgery (including subsequent abdominal surgery such as ventral hernia repair), and outpatient surgery. The cost data did not include the cost of delayed primary wound closure when performed in the office. In addition, the cost data did not include the cost of outpatient wound care supplies, visiting nursing, or cost incurred to the patient.

Univariate statistical analyses included Fisher's exact test for categorical variables and the Mann-Whitney *U* test for continuous variables. In addition, a binary logistic regression model was used to test for multivariate significance. All tests were two-sided, and a value of $p \leq 0.05$ was used to determine statistical significance. Statistical analysis was performed using SPSS for Windows Version 18.0 (SPSS, Inc., Chicago, Ill.).

Wound Care Protocol

Attending surgeons generally approached wound care similarly in the early postoperative period (weeks 2 through 6). Patients with delayed healing were instructed to conduct twice-daily superficial dressing changes with topical antibiotics or Silvadene (King Pharmaceuticals, Inc., Bristol, Tenn.). In the past 2 years, there has been a paradigm shift of long-term wound management. One attending surgeon (L.C.W.) initiated reoperative wound closure for selected patients. For those patients with impending chemotherapy or an extensive wound that remained at 6 weeks (and would otherwise require more extensive conservative wound care, i.e., deep wound packing or negative-pressure wound therapy), reoperative closure was offered. All other attending microsurgeons contributing patients in this study managed these same patients with wet-to-dry packing or negative-pressure wound therapy.

Surgical Technique

After a patient demonstrated significantly delayed wound healing and/or marked dehiscence, particularly by 6 weeks postoperatively, delayed primary wound closure was offered. This can be slightly sooner than 6 weeks if there is a particularly extensive early wound or if the medical oncologists strongly favor prompt postoperative chemotherapy in a patient with delayed healing. Delayed primary wound closure has been performed in the operating room under general anesthesia but, more commonly, this has been performed in the minor procedure room of our outpatient offices. The patient's abdominal wall is generously infiltrated with 1% lidocaine with 1:100,000 epinephrine. Devitalized soft tissue is débrided sharply with a no. 10 blade until healthy fat and well-perfused soft tissue is appreciated. Hemostasis is then achieved with electrocautery. Minimal undermining can be performed to help achieve a tension-free closure. Scarpa fascia, along with the overlying skin, is closed in layers with absorbable suture. A Jackson-Pratt drain is not typically used. Heavy polypropylene or nylon vertical mattress sutures have been selectively used; however, we have high success rates of wound closure without the consistent use of permanent skin sutures. Thus, we have avoided the additional scar burden and discomfort of suture removal without apparent consequence.

RESULTS

A total of 1218 abdominal donor sites were reviewed, and 167 patients (13.7 percent) experienced delayed abdominal wound healing.

Risk Factors for Delayed Healing at 30 Days

The 167 patients who presented with delayed healing beyond 30 days were compared with 1051 patients who were well healed at 30 days postoperatively. Multiple preoperative risk factors were identified and are listed in Table 1. The delayed healing cohort demonstrated higher rates of hypertension (31.7 versus 24.3 percent; $p = 0.039$), diabetes (10.2 versus 6.09 percent; $p = 0.049$), obesity (48.5 versus 30.4 percent; $p < 0.0001$),

Table 1. Demographic and Risk Factor Data for Those Who Were Well Healed within 30 Days of Surgery versus Those Who Demonstrated Delayed Healing Postoperatively

	Healed (%)	Delayed Healing (%)	*p*
No. of patients	1051 (86.3)	167 (13.7)	
Patient demographics			
Mean age ± SD, yr	50.6 ± 9.2	51 ± 8.93	0.207
Hypertension	255 (24.3)	53 (31.7)	0.039*
Coronary artery disease	15 (1.43)	3 (1.79)	0.864
Peripheral vascular disease	7 (0.667)	1 (0.598)	1
Dyslipidemia	174 (16.5)	36 (21.6)	0.112
COPD	10 (0.951)	5 (2.99)	0.078
Diabetes	64 (6.09)	17 (10.17)	0.049*
Obesity†			<0.0001*
Nonobese	732 (69.6)	86 (51.5)	
Class I obesity	187 (17.8)	54 (32.3)	
Class II obesity	83 (7.89)	13 (7.78)	
Class III obesity	49 (4.66)	14 (8.38)	
Obesity‡	319 (30.4)	81 (48.5)	<0.0001*
Smoking history	391 (37.2)	78 (46.7)	0.025*
Current smoker	105 (9.99)	23 (13.8)	0.152
Preoperative chemotherapy	423 (40.2)	88 (52.7)	0.009*
Bilateral reconstruction	550 (52.3)	106 (63.4)	0.024*
Flap type			0.700
TRAM	704 (69.0)	114 (68.2)	
DIEP	286 (27.2)	46 (27.5)	
SIEA	61 (5.80)	7 (4.19)	
Abdominal mesh	380 (36.2)	78 (46.7)	0.010*

BMI, body mass index; COPD, chronic obstructive pulmonary disease; TRAM, transverse rectus abdominis musculocutaneous; DIEP, deep inferior epigastric artery; SIEA, superficial inferior epigastric artery.
*Statistically significant.
†2 × 4 Fisher's exact test.
‡2 × 2 Fisher's exact test with obesity defined as body mass index >30.

smoking history (46.7 versus 37.2 percent; p = 0.025), preoperative chemotherapy (52.7 versus 40.2 percent; p = 0.009), bilateral reconstruction (63.4 versus 52.3 percent; p = 0.024), and placement of soft polypropylene mesh at the time of initial reconstruction (46.7 versus 36.2 percent; p = 0.010). Following a multivariate regression (Table 2), obesity (p = 0.001), smoking (p = 0.05), bilateral reconstruction (p = 0.008), preoperative chemotherapy (p = 0.006), and abdominal mesh (p = 0.028) remained significant factors.

Risk Factors for Delayed Healing at 3 Months among All Patients

A similar analysis was then performed on patients with delayed healing, specifically identifying factors associated with wounds that persisted beyond the 3-month follow-up visit (Table 3). Patients who underwent reoperative closure were excluded. Patients who initially presented with delayed healing but were healed by the 3-month time point were included in the healed cohort. By

Table 2. Risk Factors for Delayed Healing (30 Days) following Binary Logistic Regression

Risk Factors	*p*	OR	95% CI
Diabetes	0.232	1.43	0.793–2.59
Obesity	0.001*	1.85	1.31–2.63
Hypertension	0.267	1.24	0.847–1.82
Smoking history	0.05*	1.40	1.00–1.96
Bilateral reconstruction	0.008*	1.61	1.13–2.27
Preoperative chemotherapy	0.006*	1.61	1.15–2.25
Abdominal mesh	0.028*	1.46	1.04–2.04

*Statistically significant.

Table 3. Demographic and Risk Factor Data for Those Patients Who Were Not Healed by 3 Months Postoperatively

	Healed (%)	Not Healed by 3 Mo (%)	p
No. of patients	1142 (94.5)	67 (5.54)	
Patient demographics			
Mean age ± SD, yr	50.5 ± 9.19	53.9 ± 8.43	0.001*
Hypertension	282 (24.9)	25 (37.3)	0.021*
Coronary artery disease	15 (1.31)	3 (4.48)	0.112
Peripheral vascular disease	7 (0.613)	1 (1.49)	0.367
Dyslipidemia	190 (16.6)	19 (28.4)	0.014*
COPD	12 (1.05)	3 (4.48)	0.047*
Diabetes	71 (6.23)	10 (14.9)	0.006*
Obesity†			<0.0001*
Nonobese	782 (68.5)	31 (46.3)	
Class I obesity	212 (18.6)	27 (40.3)	
Class II obesity	91 (7.96)	4 (5.97)	
Class III obesity	57 (4.99)	5 (7.46)	
Obesity‡	360 (31.5)	36 (53.7)	<0.0001*
Smoking history	429 (37.6)	37 (55.2)	0.004*
Current smoker	120 (10.5)	8 (11.9)	0.711
Preoperative chemotherapy	471 (41.2)	37 (55.2)	0.079
Bilateral reconstruction	507 (44.4)	43 (64.2)	0.209
Flap type			0.541
TRAM	761 (66.6)	48 (71.6)	
DIEP	315 (27.6)	17 (25.4)	
SIEA	66 (5.78)	2 (2.99)	
Abdominal mesh	426 (37.3)	31 (46.3)	0.154

COPD, chronic obstructive pulmonary disease; TRAM, transverse rectus abdominis musculocutaneous; DIEP, deep inferior epigastric artery; SIEA, superficial inferior epigastric artery.
*Statistically significant.
†2 × 4 Fisher's exact test.
‡2 × 2 Fisher's exact test with obesity defined as body mass index >30.

3 months postoperatively, 67 patients remained with an open wound, and these patients were compared with the 1142 patients that were well healed at the 3-month time point. Significant factors for nonhealing at 3 months included higher mean age (53.9 years versus 50.5 years; p = 0.001) and higher rates of hypertension (37.3 versus 24.9 percent; p = 0.021), dyslipidemia (28.4 versus 16.6 percent; p = 0.014), chronic obstructive pulmonary disease (4.48 versus 1.05 percent; p = 0.047), diabetes (14.9 versus 6.23 percent; p = 0.006), obesity (53.7 versus 31.5 percent;

$p < 0.0001$), and smoking history (55.2 versus 37.6 percent; $p = 0.004$). Following a multivariate regression (Table 4), obesity ($p = 0.003$) and smoking history ($p = 0.018$) remained significant factors.

Delayed Healing Subgroup Analysis: Factors Associated with Progression to a Chronic Wound and Abdominal Wall Sequelae

A subgroup analysis was performed on all patients with delayed healing ($n = 167$) to isolate risk factors for developing a chronic wound that persisted beyond 6 months (Table 5). Patients in the delayed healing cohort who remained with a chronic wound at 6 months demonstrated higher rates of postoperative chemotherapy with an open wound (27.2 versus 6.2 percent; $p < 0.0001$), negative-pressure wound therapy (13.6 versus 0 percent; $p < 0.0001$), and wet-to-dry dressing changes (50 percent versus 15.9 percent; $p = 0.001$). In addition, patients with a more invasive flap dissection (i.e., transverse rectus abdominis musculocutaneous versus deep inferior epigastric artery versus superficial inferior epigastric artery) were also more likely to develop chronic abdominal wounds ($p = 0.047$). These patients with long-term chronic wounds had significantly higher rates of emergency room visit/hospital readmission (27.3 percent versus 4.83 percent; $p = 0.009$), scar revision (86.4 percent versus 20.7 percent; $p < 0.0001$), mesh complications (27.3 percent versus 0.689 percent; $p < 0.0001$), and hernia/bulge (18.2 percent versus 2.06 percent; $p = 0.006$).

Comparatives Outcomes of Early Reoperative Closure

Eleven patients underwent delayed primary wound closure. The mean time to surgery was 2.14 months (range, 1 to 4 months) after initial reconstruction in this cohort. Ten of the 11 patients (90.0 percent) treated with delayed primary wound closure were closed within 1 month of treatment versus 24.2 percent of those treated with conservative wound measures ($p < 0.0001$). In examining the efficacy of treatment modalities, reoperative delayed primary wound closure was compared with those who were treated with wet-to-dry dressing changes/negative-pressure wound therapy (Table 6). In comparison with those patients treated with wet-to-dry dressings or negative-pressure wound therapy, patients who underwent delayed primary wound closure demonstrated lower rates of scar revision (18.2 percent versus 66.7 percent; $p = 0.012$), mesh complication (0 percent versus 18.2 percent; $p = 0.311$), hernia/bulge (0 percent versus 12.1 percent; $p = 0.558$), emergency room visits (0 percent versus 18.2 percent; $p = 0.311$), and hospital readmission (0 percent versus 12.1 percent; $p = 0.558$). The total cost of reconstruction was lowest in the group that underwent delayed primary wound closure (Table 7), most notably in the comparison of delayed primary wound closure and

Table 4. Risk Factors for Delayed Healing of Greater Than 3 Months following Binary Logistic Regression

Risk Factors	*p*	OR	95% CI
COPD	0.162	2.65	0.676–10.4
Diabetes	0.189	1.68	0.775–3.63
Obesity	0.003*	2.54	1.33–3.82
Hypertension	0.878	1.05	0.582–1.89
Dyslipidemia	0.267	1.41	0.769–2.58
Smoking history	0.017*	1.86	1.12–3.09
Age	0.06	1.03	0.999–1.06

COPD, chronic obstructive pulmonary disease.
*Statistically significant.

Table 5. Risk Factors for Patients Who Were Not Healed by 6 Months, with Demonstration of Morbidity Associated with Chronic Abdominal Wound

	Healed by 6 Mo (%)	Not Healed by 6 Mo (%)	*p*
No. of patients	145	22	
Potential risk factors			
Diabetes	16 (11.0)	1 (4.54)	0.703
Obesity	67 (46.0)	14 (63.6)	0.17
Smoking	68 (46.9)	10 (45.5)	1
Preoperative chemotherapy	76 (52.4)	12 (54.4)	0.281
Bilateral reconstruction	89 (61.4)	17 (77.3)	0.164
Flap type			0.047*
TRAM	94 (64.8)	20 (90.9)	
DIEP	44 (30.3)	2 (9.09)	
SIEA	7 (4.83)	0 (0)	
Abdominal mesh	65 (44.8)	13 (59.1)	0.255
Initiation of postoperative chemotherapy with open wound†	9 (6.2)	6 (27.2)	<0.0001*
Débridement	13 (8.97)	9 (40.9)	<0.0001*
Negative-pressure wound therapy	0 (0)	3 (13.6)	0.002*
Silvadene dressing	58 (40.0)	11 (50.0)	0.375
Topical antibiotics	41 (28.3)	2 (9.09)	0.247
Wet-to-dry dressing changes†	23 (15.9)	11 (50.0)	0.001*
Outcomes			
ER/hospital admissions	7 (4.83)	6 (27.3)	0.009*
Scar revision	30 (20.7)	19 (86.4)	<0.0001*
Mesh extrusion/removal	1 (0.689)	6 (27.3)	<0.0001*
Hernia/bulge	3 (2.06)	4 (18.2)	0.006*
Mesh complication or hernia/bulge	4 (2.76)	9 (40.9)	<0.0001*

TRAM, transverse rectus abdominis musculocutaneous; DIEP, deep inferior epigastric artery; SIEA, superficial inferior epigastric artery; ER, emergency room.
*Statistically significant.
†Risk factor remained significant following binary logistic regression for multivariate significance.

Table 6. Comparison of Reoperative Delayed Primary Wound Closure versus Other Conservative Treatment Modalities

	Reoperative Delayed Primary Closure (%)	Wet-to-Dry or Negative-Pressure Wound Therapy Dressings (%)	*p*
No. of patients	11	33	
Outcomes			
Closed within 1 mo of treatment modality	10 (90.9)	8 (24.2)	<0.0001*
Closed within 6 mo of surgery	10 (90.9)	21 (63.6)	0.086
Failure of treatment†	2 (18.2)	23 (69.7)	0.005*
Scar revision	2 (18.2)	22 (66.7)	0.012*
Mesh extrusion/removal	0 (0)	6 (18.2)	0.311
Hernia/bulge	0 (0)	4 (12.1)	0.558
ER visits	0 (0)	6 (18.2)	0.311
Hospital readmission	0 (0)	4 (12.1)	0.558

ER, emergency room.
*Statistically significant.
†Failure of treatment was defined as the need for reoperative surgery and/or an open wound >6 mo after initial surgery.

negative-pressure wound therapy ($35,166 versus $21,097; $p = 0.043$).

DISCUSSION

There have been numerous previous studies on donor-site morbidity in abdominally based free flap breast reconstruction. These studies, however, focused on long-term hernia rates and abdominal wall function.[18–28] The above-mentioned studies were critical in establishing the safety of the abdominal donor site, and fortunately have yielded inordinately low rates of hernia and dysfunction. Given the low incidence of functional morbidity, routine postoperative management of the abdominal donor site is almost entirely that of local wound care.

Our institutional rate of delayed healing was found to be 13.7 percent. The rate of delayed healing in this study is in accordance with a recent meta-analysis by Salgarello et al.[29]; however, the reported rate of delayed healing in this study appears to be on the higher end of normal. Higher than expected rates of delayed healing are likely a reflection of the increasingly high threshold for offering this procedure to patients with a wide disparity of prior comorbidities and those patients with higher body mass indices. Our institution has published extensively on performing free flap breast reconstruction on higher risk patients and consistently demonstrated rates of thrombosis and flap failure to be comparable to healthier cohorts.[30–35] However, it should be noted that operating on these higher risk patients has not been without consequence. The repercussions of performing surgery may be manifested in other ways—notably and pertinent to this study, it becomes apparent when examining abdominal wall healing.

Patient selection factors predictive of early wound complications have been previously established both in the previously mentioned breast reconstruction literature and similarly when examining abdominoplasty.[36,37] The finding in this study of smoking and obesity as wound healing risk factors is neither novel nor surprising. Also of note, though, is that those patients who were not entirely healed at 30 days tended to have underlying polypropylene mesh and higher rates of preoperative chemotherapy and bilateral reconstruction (perhaps related to suboptimal constitution and increased wound tension, respectively). When examining those who were not healed at 3 months versus all patients, similar risk factors were identified. As one may suspect, those factors that may have been more transient insults in the immediate postoperative period—preoperative chemotherapy and bilateral reconstruction—were no longer predictive of 3-month wounds as they were predictive of wounds not healed at 30 days. Interestingly, more persistent, enduring comorbidities (e.g., more advanced age, chronic obstructive pulmonary disease) (Table 3) were predictive of the cohort who had an open wound at 3 months postoperatively.

The remainder of the findings in this study were both more novel and instructive. In examining the 167 patients with delayed healing, multiple

Table 7. Comparison of the Total Cost of Reconstruction for Those Treated with Delayed Primary Wound Closure versus Wet-to-Dry Dressing versus Negative-Pressure Wound Therapy

	Intervention			Subgroup Comparison of Cost	
	NPWT	DPWC	Wet-to-Dry Dressing	NPWT vs. DPWC (*p*)	DPWC vs. Wet-to-Dry Dressing (*p*)
Total cost of reconstruction	$35,166.66 ($11,756.24)	$21,097.30 ($5962.93)	$23,345.12 ($9141.46)	0.0425	0.3678

NPWT, negative-pressure wound therapy; DPWC, delayed primary wound closure.

factors were predictive of progression to a chronic wound that remained open at 6 months postoperatively. Among the delayed healing subgroup of 167 patients, comorbidities were not predictive of progression to a chronic nonhealing wound lasting longer than 6 months. Instead, the extent of the fascial dissection during flap harvest (i.e., flap type) and postoperative treatment modalities were the most predictive factors of progression to a long-term chronic wound. Initiation of postoperative chemotherapy with an open wound was decidedly predictive of chronic abdominal wounds. Although the timing and decision-making of initiating chemotherapy can be complex, it remains inadvisable to initiate chemotherapy in patients with an open wound.

Aside from initiation of chemotherapy and flap type, wound care treatment modalities (débridement, wet-to-dry dressing changes, and negative-pressure wound therapy) were all associated with persistently open wounds. This of course does not demonstrate causation, nor is it evidence regarding the efficacy of débridement, wet-to-dry dressing changes, or negative-pressure wound therapy. Rather, this is likely more of a reflection of the wound size. If a wound was débrided (i.e., made larger) or thought to be extensive enough to require wet-to-dry dressing changes or negative-pressure wound therapy, it was likely to persist for 6 months. Thus, if a patient has a wound that is extensive enough to necessitate implementation of wet-to-dry dressing changes or negative-pressure wound therapy, these patients may be better served with a more aggressive reoperative approach. After caring for multiple patients with longstanding chronic abdominal wounds at our institution, selected patients have recently been returned to the operating room for early intervention by means of delayed primary wound closure. Clearly, not all patients with delayed healing require reoperation. Ultimately, these are likely the best selection factors—more invasive fascial dissection (i.e., transverse rectus abdominis musculocutaneous flap), impending postoperative chemotherapy, or a wound that would otherwise require more involved conservative wound measures (e.g., negative-pressure wound therapy or wet-to-dry dressing)—for implementing delayed primary wound closure.

Although these patients may eventually heal with these more conservative treatment modalities, long-term chronic abdominal wounds were demonstrated to be strongly associated with more significant abdominal wall sequelae (Table 5). Aside from markedly higher rates of emergency department visits and admissions (and undoubtedly lower patient satisfaction), these patients experienced unequivocally higher rates of eventual mesh complications/hernia. Likely secondary to having prosthetic mesh and a chronic open wound, over 40 percent of patients experienced mesh complications/hernia when not healed by 6 months. This is an unacceptably high rate of major abdominal wall sequelae for elective reconstruction. Delayed primary wound closure may be a much needed strategy to reduce this high complication rate.

Even so, an overwhelming majority of patients with chronic wounds eventually were returned to the operating room for revision of a resultant widened/unstable abdominal scar regardless of whether or not they had a mesh complication/hernia. Microsurgical breast reconstruction retains the need for optimal aesthetic outcomes, and allowing large areas to fill secondarily counteracts a reasonable aesthetic outcome. Therefore, in making the case for early reoperative closure, it appears that reoperation at some later point in time is essentially inevitable (Fig. 3). By intervening early, the surgeon may be simply débriding and reapproximating the wound rather than performing an extensive repair of the abdominal wall.

When comparing those patients treated with delayed primary wound closure versus traditional conservative measures, delayed primary wound closure patients had significantly higher success rates and lower rates of scar revision (Table 6). Nearly all patients (90.9 percent) were well healed within 1 month of treatment. In selecting patients for early débridement and closure, our data suggest that later, more extensive reoperative surgery is avoided with the added benefit of a more optimal postoperative recovery, namely, fewer office visits, fewer readmissions, and avoidance of the high-cost of chronic wound management. Although not yet statistically significant, it bears mentioning that no patient who has undergone delayed primary wound closure has experienced a hernia/bulge, mesh complication, or hospital readmission. What was significant, however, was the difference in total cost of reconstruction. Those treated with delayed primary wound closure had a much lower total cost of reconstruction, particularly when compared with those treated with negative-pressure wound therapy.

It is partly unclear why nearly all delayed primary wound closure patients healed on reclosure but did not heal following the initial operation. The first explanation could be technical error. Some of these cases may represent poor closure that was then rectified by the attending microsurgeon. More likely, there are cases in which poor wound healing occurs despite meticulous technique. In these

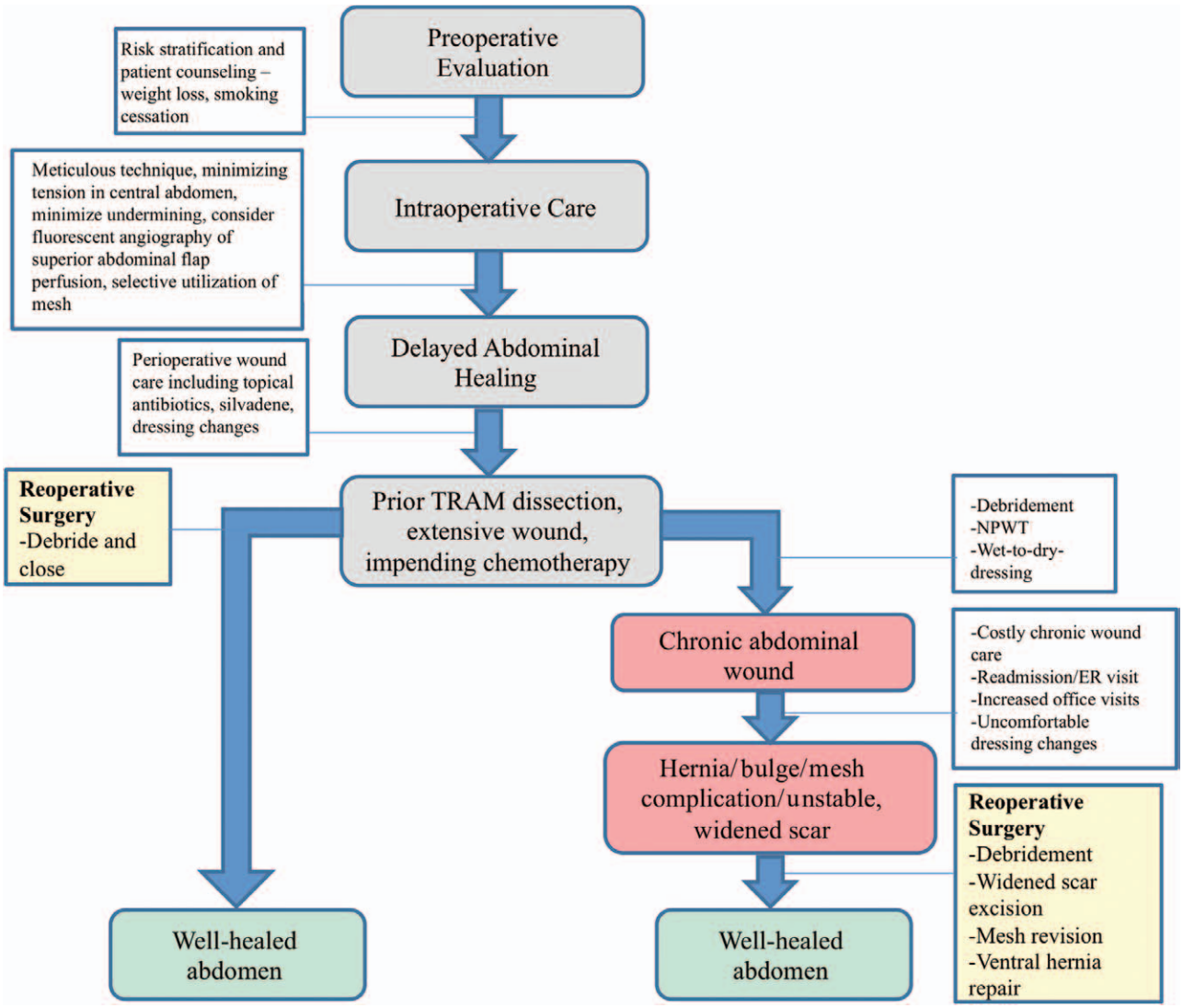

Fig. 3. Treatment diagram demonstrating multiple potential intervention points to achieve a well-healed abdomen. Even patients with a chronic abdominal wound progress to a well-healed abdomen; however, implementing ineffective strategies results in multiple adverse outcomes. For those in whom preventive measures were not effective and who present with a prior transverse rectus abdominis musculocutaneous (*TRAM*) flap dissection (as opposed to more fascia-sparing flaps such as deep inferior epigastric artery or superficial inferior epigastric artery), an extensive wound, or impending chemotherapy, reoperative surgery (*yellow*) is nearly inevitable. By proceeding with an early, aggressive operative approach, negative outcomes may be avoided. *NPWT*, negative-pressure wound therapy; *ER*, emergency room,

cases, perhaps the ephemeral physiologic insult of lengthy surgery (e.g., hypotension, edema) and/or transiently devascularized abdominal flaps are both factors that improve by the time that delayed primary wound closure occurs. Lastly, there may be some element of mechanical/biological creep that decreases central wound tension on delayed primary wound closure. Regardless of exactly why this has been efficacious, delayed primary wound closure has been successful in reducing readmissions, improving aesthetic outcomes, avoiding long-term abdominal wall sequelae, and ultimately improving patient satisfaction.

The study does suffer from certain limitations. Other than flap type and impending chemotherapy, there exists subjective decision-making in deciding to offer delayed primary wound closure. The data suggest that an extensive wound that would otherwise require deep wound packing or negative-pressure wound therapy is best served with delayed primary wound closure; however, this remains a subjective decision. Nonetheless, these factors do serve as practical criteria for decision making. Ideally, there would be objective wound depth and area measurements that are lacking in this study and could more accurately guide decision making. Of note also is that the

CODING PERSPECTIVE

This information provided by Dr. Raymond Janevicius is intended to provide coding guidance.

13101-78	Complex repair, trunk; 2.6 cm to 7.5 cm
13102-78	Complex repair, trunk; each additional 5 cm or less

- The abdominal wound is debrided and closed in layers. This constitutes a complex repair, so codes 1310X are used. The débridement is not separately reported, as it is included in the complex repair codes.
- The procedure is coded by final length of closure. Thus a wound closure of 25 cm uses base code 13101 for the first 1.5 cm, with add-on code 13102 reported once for each subsequent 5 cm or less: 7.5 cm + 5 cm + 5 cm + 5 cm + 5 cm = 27.5 cm. Thus:

  13101-78
  13102-78
  13102-78
  13102-78
  13102-78

- Some payers prefer a one-line entry per code with 4 in the units box:

  13101-78 (1 unit)
  13102-78 (4 units)

- Because this is an *unplanned return to the operating room for a related procedure during the postoperative global period*, append modifier 78 to each code. Since the procedures occur during the postoperative global period, reimbursement for codes 13101 and 13102 will be reduced from the allowable.
- If the procedure is performed in the office, many payers, including Medicare, will not reimburse for this procedure, as the treatment of all complications that do not require a return to the operating room are included in global postoperative care.
- Delayed primary would closure as described in the article is not to be reported with the flap codes (14XXX), as this is not an adjacent tissue transfer. Even if the abdominal flap is undermined for closure, this is not considered an adjacent tissue transfer to be reported with codes 14XXX.

cost data captured only inpatient costs, outpatient surgery costs, and costs incurred in the emergency room. The cost data for delayed primary wound closure performed in the office were not captured; however, this was essentially limited to the cost of suture, sterilization of instruments, and local anesthetic. Altogether, the cost data likely grossly underestimate the cost benefit of delayed primary wound closure because the other factors are excluded (e.g., home wound nursing, wound care supplies, lost surgeon time). Also, this study does not provide objective patient satisfaction data. Lastly, given that delayed primary wound closure reflects a more recent paradigm shift, a relatively small percentage of patients have undergone early reoperative closure. Many outcomes comparing treatment strategies were not statistically significant, and this is likely a result of an underpowered statistical comparison. To ensure adequate follow-up for the outcomes measures in comparing delayed primary wound closure versus conservative wound care (i.e., scar revision and hernia), a significant number of more recent patients who underwent delayed primary wound closure were excluded from this study. Anecdotally, it bears mentioning that these more recent patients have similarly done exceedingly well, and as a result, delayed primary wound closure is now more widely used.

CONCLUSIONS

The abdominal donor site remains the criterion standard in microsurgical breast reconstruction. Unfortunately, the low transverse abdominal incision can become problematic secondary to postoperative wound complications. Preventing these complications and optimally treating their inevitable occurrence is essential to patient satisfaction and avoidance of long-term abdominal wall sequelae. More recently at our institution, early reoperative primary wound closure has been successfully and selectively implemented, resulting in improved patient outcomes.

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