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ORIGINAL ARTICLE

Risk factors for mastectomy flap necrosis following immediate tissue expander breast reconstruction

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Abstract

Tissue expander placement is a mainstay of reconstructive surgery in the post-mastectomy patient. Necrosis of the native breast tissue is one of the most significant concerns in their post-operative care. The goal of this study is to elucidate factors that confer risk of this outcome. Chart review was conducted for a consecutive series of immediate tissue expander reconstructions by the two senior authors. Data was collected for several preoperative and intraoperative variables, as well as the outcome of mastectomy flap necrosis. Of the 1566 breasts that were examined, 135 (8.6%) experienced flap necrosis. The cohorts with and without flap necrosis were well matched. Those with the outcome of interest had significantly higher rates of switching to an autologous method of reconstruction (31.9% vs 6.2%, $p < 0.001$). Regression analysis revealed smoking status, increased age, tumescent mastectomy technique, and high (>66.67%) intraoperative tissue expander fill to confer increased risk of mastectomy flap necrosis. While smoking and older age are well-supported by the literature, tumescent technique and tissue expander fill are more novel points of discussion, which may serve as proxies for other issues. Awareness of these risk factors and their interplay will aid in clinical judgement and postoperative care of these patients.

Key Words: Breast reconstruction, mastectomy flap necrosis, risk factors, smoking, tumescent technique, tissue expander

Introduction

There has been an increasing focus on both therapeutic and prophylactic mastectomies in the last decade [1–5]. These patients experience a plethora of psychosocial benefits from reconstruction [6,7]. Since 2002, implant-based reconstruction has grown increasingly more common than its autologous counterpart [5,8]. Several studies have presented risk factors for surgical site complications following expander/implant reconstruction, including hypertension, smoking, obesity, radiation exposure, surgical duration, and operative technique [9–14].

Mastectomy flap necrosis is one of the most common complications of expander/implant reconstructions, and treatment entails at the least prolonged wound care, and at the most additional surgical intervention for débridement and even explantation [15–18]. This can have a significant impact on recovery and delay adjuvant therapies. Further, it can lead to unfavourable reconstructive outcomes and numerous revision surgeries. Despite the importance and frequency of flap necrosis, few studies have elucidated specific risk factors. Padubidri et al. [19], as well as Pinsolle et al. [20], showed an increased risk in smoking cohorts. Other studies have previously demonstrated increased risks with a variety of perioperative and intraoperative factors [21–23]. The current study is a single-institutional review of immediate two-stage breast reconstructions, with the goal of assessing preoperative, intraoperative, and postoperative risk factors for mastectomy skin flap necrosis.

Methods

Data collection

A chart review was performed with the approval of the Northwestern University Institutional Review Board. Data was collected for a consecutive series of patients undergoing two-stage expander–implant breast reconstruction by the senior authors at Northwestern Memorial Hospital, between January 2004 and August 2012. These reconstructions entailed the initial placement of a tissue expander in a submuscular pocket, created by dissecting the pectoralis major from its lateral towards its medial and inferior insertions, with additional coverage by serratus fascia or acellular dermal matrix (ADM) where necessary. Demographic and comorbid variables for each patient – including age, BMI, smoking status, and hypertension – were recorded, along with preoperative or postoperative radiation to the breast. Intraoperative expander fill percentage (calculated based on total expander volume) and acellular dermal matrix (ADM) use were also recorded for stage I procedures. Outcomes of interest tracked for each breast included mastectomy flap necrosis (defined by the need for sharp débridement), major infection (defined as one requiring intravenous antibiotic administration), seroma, haematoma, and complication-related explantation. All data were entered into an Excel workbook. Breasts with insufficient data with respect to outcomes of interest were excluded before the analysis.

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Table I. Clinical and perioperative characteristics.

Characteristic	Flap necrosis (n = 135)		Healthy Flap (n = 1431)		p-value
	n	%	n	%	
Age[a] (years)*					0.003
	51.0 ± 11.2		48.1 ± 10.7		
BMI[a] (kg/m^2)*					< 0.001
	27.8 ± 6.5		25.5 ± 5.5		
Smoker	19	14.1%	132	9.2%	0.068
Hypertension*	35	25.9%	216	15.1%	0.001
Premastectomy Radiation	8	5.9%	69	4.8%	0.571
Tumescent Technique*	90	66.7%	828	57.9%	0.047
ADM Use	64	47.4%	592	41.4%	0.174
Intraop. TE Fill[a] (%)*					0.001
	60.9 ± 27.6		52.5 ± 28.1		

*Significant value, $p < 0.05$.
[a]Continuous variable, reported as mean ± SD.

Statistical analysis

Breasts were grouped based on the outcome of mastectomy flap necrosis. These cohorts were assessed for similarity with respect to preoperative and intraoperative characteristics. They were then assessed for differences with respect to concomitant outcomes of interest. All categorical variables were analyzed using the Fisher's Exact test and the chi-squared test in computationally expensive cases and all continuous variables were analyzed using independent sample t-tests. Binomial logistic regression was used to control for confounding variables. Regression analysis yielded independent odds ratios for the outcomes of interest with respect to each preoperative and intraoperative characteristic that was included. All statistical analysis was carried out with SPSS version 21.0.0 (IBM).

Results

Data collection

A total of 1566 breasts, among 1221 patients, met all inclusion criteria, after exclusion of 29 breasts for insufficient data regarding the outcome of interest. Of these, 135 (8.6%) experienced mastectomy flap necrosis, and 1431 (91.4%) did not. Mean follow-up was 21.8 months after stage I.

Statistical analysis

Demographics and comorbidities that had statistically significant differences included only age, BMI, and hypertension (Table I). The cohort with necrosis was on average older (mean age ± SD = 51.0 ± 11.2 vs 48.1 ± 10.8, p = 0.003) and heavier (mean BMI ± SD = 27.8 ± 6.5 vs 25.5 ± 5.5, $p < 0.001$), with a higher rate of hypertension (25.9% vs 15.1%, p = 0.001). Both intraoperative fill percentage and tumescent mastectomy technique also had statistically significant differences. Breasts with mastectomy flap necrosis were more likely to have undergone tumescent mastectomy (66.7% vs 57.9%, p = 0.047) and to have greater initial tissue expander filling (mean ± SD = 60.9 ± 27.6 vs 52.5 ± 28.1, p = 0.001). Other characteristics including smoking, premastectomy radiation, and ADM use had statistically insignificant differences, also displayed in Table I.

A flow diagram depicting surgical management of the two cohorts is depicted in Figure 1. Of the cohort with mastectomy flap necrosis, 31.9% were switched to an autologous method of reconstruction, compared to only 6.2% of the other cohort.

The results of the regression analysis are displayed in Table II. The regression model indicated significant preoperative risk factors of age (OR = 1.02, 95% CI = 1.001–1.04) and active smoking (OR = 2.01, 95% CI = 1.16–3.48). Intraoperative risk factors were tumescent technique (OR = 1.49, 95% CI = 1.001–2.22) and >66% intraoperative TE fill (OR = 1.73, 95% CI = 1.03–1.57). All four of these risk factors reached statistical significance at p-values ≤ 0.05.

Discussion

Flap necrosis is a common complication in mastectomy patients and is often due to vascular compromise of the native breast skin following dissection of the breast tissue [24-26]. This presents a particular issue in immediate breast reconstruction, in which devices add increased stress to already traumatized tissue [18,25]. Literature rates of mastectomy flap necrosis following immediate reconstruction range from 8.7–22%, largely due to

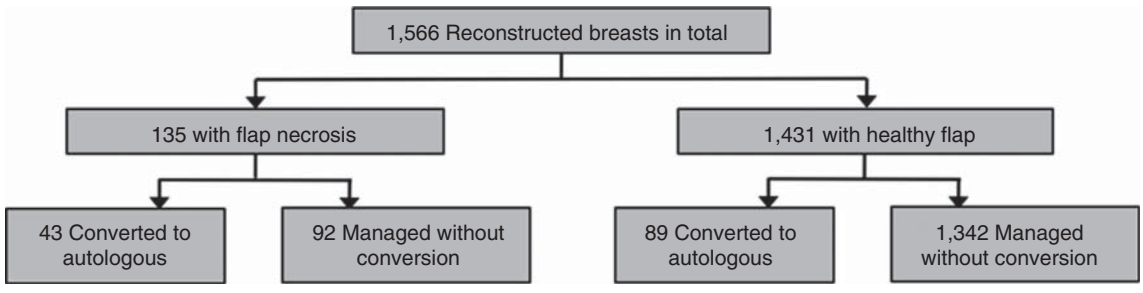

Figure 1. Breasts converted to autologous reconstruction; 31.9% of breasts with flap necrosis were switched to autologous reconstructions over the course of their management, compared to 6.2% of breasts with healthy flaps.

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Table II. Regression analysis of risk factors for flap necrosis.

Potential risk factor	*p*-value	Odds ratio	95% CI Upper	95% CI Lower
Age*	0.036	1.021	1.001	1.040
Obesity	0.376	1.227	0.780	1.929
Active Smoker*	0.013	2.005	1.156	3.478
Hypertension	0.111	1.498	0.911	2.464
Pre-mastectomy Radiation	0.648	1.227	0.511	2.946
Tumescent Technique*	0.050	1.490	1.001	2.218
Intraoperative TE Fill*				
<33.33%	*Reference Category*			
33.33%–66.66%	0.282	1.35	0.78	2.32
>66.66%*	0.040	1.73	1.03	2.91
ADM Use	0.754	1.064	0.721	1.570

*Significant value, $p < 0.05$.
c-statistic = 0.637; H-L statistic = 0.720.

variation in mastectomy technique and definition of the outcome [15,18,26–28]. We found in the current assessment that 135 mastectomy flaps (8.6%) were complicated by a degree of necrosis that necessitated surgical débridement. Breasts with mastectomy flap necrosis had significantly higher rates (31.9% vs 6.2%, $p < 0.001$) of switching to an autologous reconstruction, as would be expected in the management of severe cases [16,17]. Our analysis revealed four independent risk factors for mastectomy flap necrosis: Smoking, increased age, tumescent mastectomy technique, and high intraoperative expander fill.

The current findings provide further validation of the risks associated with smoking, which are numerous and well established in the reconstructive surgery literature [15,19,20,29,30]. Padubidri et al. [19] characterized the complications in transverse rectus abdominus myocutaneous and prosthetic reconstruction, stratifying patients by smoking status. In the series of 748 patients, they found a correlation between smoking and both mastectomy flap necrosis and (in autologous patients) donor site necrosis. Pinsolle et al. [20] had similar findings in a study of 266 patients undergoing immediate reconstruction with latissimus dorsi myocutaneous flaps and/or implants. This study showed that smoking correlates with not only skin necrosis, but also reconstructive failure. However, neither of these studies controlled for possible confounders with further statistical analysis.

Goodwin et al. [29] made a specific examination of smoking in the setting of expander/implant reconstruction, with additional analysis to control for confounding. In the series of 515 patients, smoking was found to be an independent risk factor for postoperative complications. A later study of 1170 expander/implant reconstructions at the same institution, by McCarthy et al. [15], showed smoking to be one of four independent risk factors for complications. However, neither of these studies examined independent risk factors for mastectomy flap necrosis specifically. The current study suggests an independent 2-fold risk increase in smokers. This is not a surprising finding, given the extensive body of knowledge surrounding the effects of smoking in the setting of surgery. Tobacco smoke contains a variety of toxins that hamper wound healing. Most notably, Padubidri et al. [19] points out that the duo of carbon monoxide, which decreases the oxygen carrying capacity of blood, and nicotine, which causes inhibition of capillary blood flow in the first place, work together to severely impair tissue oxygenation [31–33]. The systemic hypoxia associated with smoking impairs the healing of undermined breast skin and predisposes these patients to flap necrosis.

The current study showed an independent risk increase of 50% in breasts undergoing tumescent mastectomy. The use of this technique, whereby the surgeon injects a solution of anaesthetic and crystalloid into the subcutaneous space to facilitate the quick development of skin flaps, was first described in the context of mastectomy in 1996 [34]. Some oncologic surgeons find this technique beneficial for its decreases in operative time, blood loss, and perioperative pain [35]. However, recent literature suggests that certain risks are associated with tumescent mastectomy. Chun et al. [21], in a study of 380 consecutive mastectomies with immediate reconstruction, showed the tumescent technique to be an independent risk factor for full-thickness necrosis that required sharp débridement. A subsequent study of 1217 mastectomies with immediate reconstruction at our institution, by Seth et al. [22], further substantiated this finding; however, they noted that less than 25% of breasts with native skin flap necrosis had other risk factors as well. Possible explanations for the technique's detrimental effect lie in some of the same factors that make it advantageous: namely, the epinephrine-induced vasoconstriction that leads to decreased blood loss. While the decreased tissue perfusion that accompanies the vasoconstriction is short-lived, some prior studies suggest that even intraoperative tissue perfusion is an indicator of skin flap viability [26,36]. Abbott et al. [23] found tumescence *not* to be a risk factor for mastectomy flap necrosis, although the study was hampered by a sample size of only 134 patients and a combination of immediate and delayed reconstructions. While our findings are consistent with the studies by Chun et al. [21] and Seth et al. [22], it is limited by a lack of control for potential confounders related to the technique and experience of the breast surgeon.

In our study, increasing age was another risk factor for mastectomy flap necrosis. Age may confer a risk of a variety of complications in expander/implant reconstruction. McCarthy et al. [15], in the same study that examined smoking status, also found age greater than 65 to be a predictor of complications. A previous study by our group of tissue-expander reconstruction, using a large scale clinical outcomes database, showed age greater than 50 to be a risk factor for

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Table III. Odds ratios for previously found risk factors for flap necrosis.

Reference	Smoking	Tumescence	Age[a]	BMI[a]	Prior radiation
Seth et al. [22]	2.09	1.57	2.03	2.23	—
Chun et al. [21]	—	3.93	1.59	1.11	3.19
Pinsolle et al. [20]	0.02[b]	—	—	—	—
Goodwin et al. [29]	3.13	—	—	—	—
Zimmermann-Nielsen et al. [30]	4.9	—	—	—	—

[a]Cutoffs differ between papers for continuous variables.
[b]*p*-value reported, rather than odds ratio, due to lack of regression analysis.

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surgical site morbidity [11]. Some studies have addressed the relationship of age to mastectomy flap necrosis, specifically. The study of tumescent technique by Chun et al. [21], in controlling for confounders, revealed increasing age to be a predictor of necrosis (odds ratio = 1.59 per 10-year increment, $p = 0.001$). Similarly, the study of tumescent technique by Seth et al. [22] found age greater than 50 to be a predictor of flap necrosis (odds ratio = 2.03, $p < 0.001$). With age comes local and systemic effects that decrease both the speed and quality of wound healing [37-39]. In addition, the thickness of the skin flap, which may be decreased in elderly patients with thinner skin, is important to its viability [40]. The combination of these effects may predispose older patients to a higher rate of mastectomy flap necrosis.

The final factor that was found to confer significant risk in our analysis was high intraoperative expander filling. This was assessed relative to the total expander volume; that is, breasts with expanders that were initially filled to greater than 66.67% of their total volume were at a 73% increased risk of subsequent mastectomy flap necrosis. A similar analysis was done by Crosby et al. [18], in a retrospective study of 164 patients undergoing tissue expander reconstruction. They found a significant difference between mean percentage fill in patients with and without complications ($p = 0.025$). However, the differing rates in McCarthy et al.'s [15] study did not extend specifically to mastectomy flap necrosis.

Intraoperative fill percentage is a complex variable that, in our analysis, may serve as a proxy for two other potential risk factors. On one hand, high initial filling of tissue expanders could represent compression of the tenuous blood supply of the leftover skin flap [18,41]. This is in keeping with previous recognition of excessive closing tension as a risk factor for flap necrosis [36]. On the other hand, higher intraoperative fill could represent cases in which the mastectomy flaps were longer, and actually *required* more filling relative to the expander size in order to adequately inflate the remaining tissue. The distal edges of longer flaps are further from the blood supply where the skin is attached to the chest wall, and are more susceptible to ischaemic damage. High intraoperative filling likely represents a combination of both closing pressure and flap length, neither of which we were able to control for in this study.

Notably, obesity and prior radiation are previously described risk factors that were not shown to be significant in our study. This is not the first study in which these factors have been found to be insignificant, although there are a few possible explanations. Given that both BMI and prior radiation rates were higher in the flap necrosis cohort, a larger sample size may have proven these risk factors significant. Additionally, variability in surgeon technique may play a role in controlling these risk factors. For example, reconstructive surgeons may be more cautious with intraoperative filling of a previously irradiated breast, a variable that was found to be significant in our analysis. Also, obesity is generally accompanied by longer skin flaps, and thus an increased risk of necrosis along the distal edge. Reconstructive surgeons may excise the native skin to varying degrees, attenuating this difference. A summary of pertinent findings from similar studies has been provided in Table III for ease of reference.

There are a few limitations to the current study that we wish to acknowledge. Its retrospective nature precludes it from taking into account certain intraoperative variables, like the length and thickness of the native breast skin flap. Additionally, intraoperative perfusion, as measured by recently supported techniques like indocyanine green fluorescence angiography, was not measured in this cohort [42]. A prospective analysis of mastectomy flap necrosis taking into account these variables would provide useful validation of our findings. In addition, this study was conducted at a single, high-volume centre; thus, the rates of flap necrosis and the exact risk ascribed to different risk factors may not be generalizable. These limitations notwithstanding, the results of this study may help inform decision-making of both oncologic and reconstructive surgeons, as well as elevate appropriate clinical suspicion of flap compromise in postoperative care of the mastectomy patient.

Mastectomy flap necrosis represents a significant portion of the morbidity associated with tissue expander breast reconstruction. While some recent literature advocates the use of intraoperative imaging to determine adequate tissue perfusion, the expensive technology can only serve to assist the clinical judgement of the reconstructive surgeon. Ultimately, the information presented in this study can aid in that judgement. Smoking status, increased age, tumescent mastectomy, and high intraoperative tissue expander fill are all independently associated with increased risk of flap necrosis in the post-mastectomy patient. Awareness of these risk factors, what they represent, and their interplay, will aid both surgical technique and postoperative care.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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