

*LITERATURE REVIEW*

# Diagnosis and Management of Areolar Ischemia

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*Transient areolar ischemia occurs as a consequence of all breast lift/reduction procedures. Most commonly, it results in no complications or cosmetic consequences. Prolonged or more moderate ischemia results in cutaneous edema and epidermolysis in approximately 5–11% of patients. Complete full-thickness areolar necrosis has been reported to occur in approximately 0.5–7.3% of all cases of cosmetic, oncologic, or reconstructive breast surgery. Despite this unavoidable fact, there does not appear to be any literature focused on the diagnosis and management of this well-documented complication. We present this paper as a review of the current literature and as a way to establish a standard of management of areolar ischemia and necrosis.*

**T**ransient areolar ischemia occurs as a consequence of all breast lift/reduction procedures. Most commonly, it results in no complications or cosmetic consequences. Prolonged or more moderate ischemia results in cutaneous edema and epidermolysis in approximately 5–11% of patients.<sup>1–3</sup> Complete full-thickness areolar necrosis has been reported to occur in approximately 0.5–7.3% of all patients of cosmetic, oncologic, or reconstructive breast surgery.<sup>4–7</sup> Normal anatomic variation, venous congestion, arterial insufficiency, surgical misadventure, pedicle kinking, suture obstruction, edema, simultaneous implant prosthesis placement, hematoma, thrombosis, and infection have been reported as causative.<sup>8</sup> Factors associated with increased risk of areolar ischemia are listed in Table 1.

The literature is replete with publications focused on anatomic study to improve predictability of the venous and arterial vasculature of the nipple areolar complex (NAC).<sup>9–14</sup> Others have attempted to identify risk factors and develop risk stratification of patients

undergoing breast surgery in order to assist in awareness for patients and surgeons of the inherent risks of surgery. The undeniable fact remains that up to 7.3% of all patients undergoing breast lift or reduction result in ischemia and possible complete necrosis.<sup>4–7</sup> Despite this unavoidable fact, there does not appear to be any literature focused on the diagnosis and management of this well-documented complication. We present this paper as a review of the current literature and to establish a standard of management of areolar ischemia and necrosis.

## Risk Factors Contributing to Complications of Areolar Necrosis

### *Regional Vascular Anatomy*

Arterial insufficiency is a major contributor to NAC necrosis. In performing reconstructive breast surgery or mastopexy procedures, one needs to be cognizant of the vasculature of the breast. The breast receives arterial supply from multiple sources that intertwine in a rich anastomotic network. Since the early studies by Manchot and many others that followed, we know that the breast is perfused by internal thoracic artery (internal mammary artery), lateral thoracic artery, thoracoacromial artery, anterior intercostal arteries, and posterior thoracic arteries<sup>4,15,16</sup> (Figure 1). Whereas the heart can be described to be “left dominant” or “right dominant,” the breast tissue can be similarly categorized to have medial dominance, lateral dominance, or inferior dominance depending on the location of the main arterial source.<sup>4</sup>

Knowledge of the dominant arterial and venous supply of the breast would help the surgeon design the most robust flap. Economic reality and risks prevent standard vascular studies of all the patients prior to their breast surgeries. Since the breast has many different sources of arterial supply, different tissue flaps have been used for surgery. The main flaps advocated by many authors include medial, lateral, inferior, and superior. Not surprisingly, these flaps correspond with the physical location of the different arterial sources.

Received for publication December 14, 2011.

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DOI: 10.5992/AJCS-D-11-00062.1

**Table 1. Risk Factors Contributing to Complications of Areolar Necrosis**

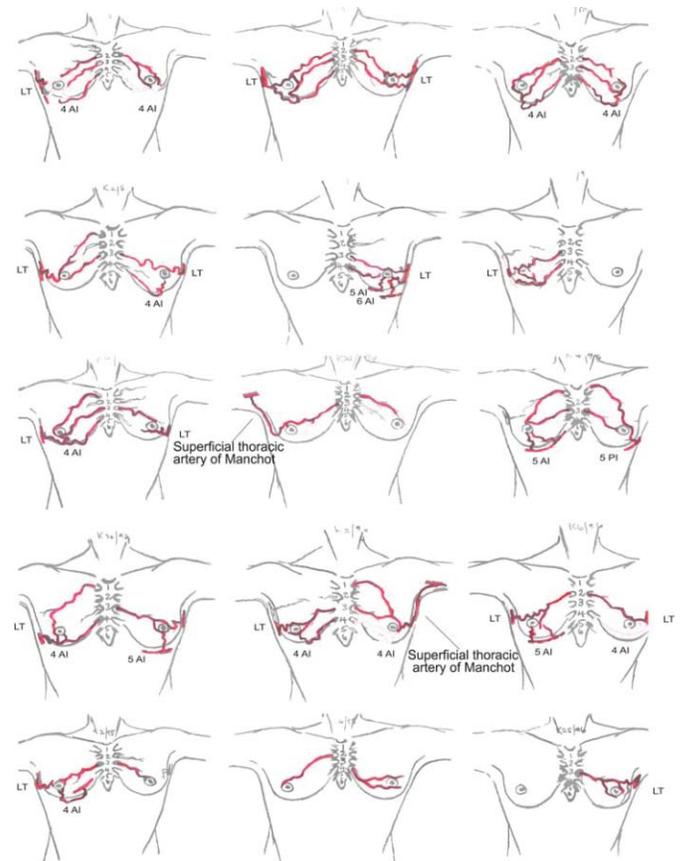
1. Body mass index above ideal
2. Diabetes
3. Hypertension
4. Past history of poor wound healing
5. Current or recent smoking
6. Density of breast tissue
7. Patient age >40 years
8. Sternal notch to nipple length
9. Mass of excised breast tissue
10. Genetic predisposition to thrombosis
11. Malignancy
12. Inadequate preoperative antibiotic regimen
13. Simultaneous insertion of implant prosthesis
14. Previous chest radiation therapy
15. Low hematocrit requiring transfusion
16. Immune modulating medications

Many more authors advocate a combination of the main flaps, thereby creating the superior-lateral, superior-medial, and so on.<sup>4</sup> Combination flaps theoretically provide greater perfusion to the areolar complex, decreasing the likelihood of NAC necrosis. Even with meticulous design of the breast flap, necrosis of the NAC cannot be prevented 100%. Within the same patient, the left and right breast may have different dominant arterial sources.<sup>9</sup>

The venous system of the breast follows the same general course as its arterial counterparts and consists of a superficial and deep system.<sup>17</sup> The deep and superficial venous system of the breast forms a rich collateral network of venous outflow, draining the breast from a deep to superficial plane.<sup>18</sup> It has also been noted that breast tissue may have lateral or medial dominance in terms of venous drainage.<sup>18</sup> Most of the venous outflow from the breast exits through the superficial drainage system of the breast.<sup>19</sup> Arteries of the breast tend to be in a deeper plane, whereas the venous system stays in a more superficial plane, much like in the rest of the body. In theory, a thick flap that incorporates the most arteries and arterioles will also have the most veins and venules. Le Roux et al<sup>20</sup> advocate the use of the superomedial flap, owing to its robust venous supply.

#### *Pedicle Length*

Pedicle length is directly proportional to the size of the breast and the severity of breast ptosis. It is not uncommon to have long NAC pedicles when



**Figure 1.** Pattern of areolar blood supply of 27 cadavers. Note variations of the left and right nipple areolar complex vasculature even in the same patient. (With kind permission from Springer Science+Business Media. van Deventer PV, Page BJ, Graewe FR. The safety of pedicles in breast reduction and mastopexy procedures. *Aesthetic Plast Surg.* 2008;32:307–312.)

reconstructing hyperplastic breasts just as seen in severely ptotic breasts. This increase in pedicle length is reflected in the suprasternal notch to nipple distance (SSN:N). Longer pedicles are associated with increased vascular compromises.<sup>21</sup> Survivability of the NAC with long pedicles has to do with the amount of pedicle kinking when performing areolar repositioning—often, longer pedicles will have excessive kink to accommodate its new NAC location.<sup>21</sup> It seems that SSN:N less than 30 cm tends to have fewer vascular complications.<sup>22</sup> Yet, other authors have disputed this claim.<sup>23</sup> Increased density of breast tissue will increase the likelihood of compression or malrotation of the pedicled flap. Clinical examination and documentation of density must be made and correlation to increased risk of complications discussed. Other objective methods of evaluation of density exist but remain impractical for cosmetic purposes.<sup>24</sup>

### *Volume of Reduction*

Breast reduction surgeries involve debulking the breast tissue parenchyma. Excessive reduction in breast tissue is directly proportional to the likelihood of developing a vascular compromise of the NAC. Thinning of the breast flap essentially equates to thinning of the vasculature—less residual breast parenchyma will result in less blood supply. What is the point of no return in terms of maximal breast tissue reduction? Strombeck<sup>25</sup> in 1964 suggested that resection greater than 500 g will result in higher local complications. Hawtof et al<sup>22</sup> noted a 17% overall complication rate in patients who had more than 700 g removed in each breast. Dabbah et al<sup>26</sup> observed a significant increase in postoperative complications when more than 1000 g of tissue was resected from each breast. Schnur et al<sup>27</sup> in 1997, realized a trend in his breast reduction patients—1500 g was the mean specimen weight for patients with complications, and 1329 g was the mean weight for patients without complications. Complications increased in a linear fashion with increased specimen weight; a 1200-g resection has 5 times the risk for postoperative complications as compared with a 300-g resection.<sup>28</sup>

### *Increased Body Mass Index*

Conventional thinking leads one to conclude that there may be a linear correlation between postoperative complications and increase in body mass index (BMI). Indeed, in the trauma literature, patients with higher BMI had an increased risk for sepsis.<sup>29</sup> Patients with increased BMI were also more likely to have a longer hospital stay.<sup>30</sup> Numerous papers linking obesity and breast surgeries, however, showed very inconsistent results. Strombeck<sup>25</sup> concluded that patients more than 10 kg overweight were at increased risk for complications. Interestingly, in a later paper by Strombeck, he did not see any clear correlation between high BMI and postoperative complications.<sup>31</sup> Pers et al<sup>32</sup> arbitrarily divided his patient population into those less than 5% of ideal body weight (IBW) and another group that was greater than 5% IBW. A 4.6% complication rate was observed in the “heavier” group versus 0.9% in the “lighter” group. Zubowski et al<sup>28</sup> observed that patients 20% above average body weight had no higher incident of complications than the patients 5% above average weight, but they did observe a decreased complication rate in patients less than 5% above average weight. According to one study, patients who are morbidly obese do not have any additional risks as compared to nonobese patients.<sup>33</sup> It is widely accepted that BMI contributes to increased risks for

complications of breast surgery.<sup>34–36</sup> Delayed healing, wound dehiscence, and infection all have been clearly associated with increased BMI. However, we believe the esthetic outcome of surgery may not be affected by these increased complications. The recommendation has been made to continue antibiotics for a 5-day course in order to reduce dehiscence and postoperative scarring.<sup>23</sup>

### *Smoking History*

Tobacco smoking is perhaps one of the most easily preventable risk factors in surgical candidates. Not only does it decrease the overall pulmonary function of the patient, it also decreases perfusion to the body’s periphery. Smoking has been implicated as a causative agent for many cardiovascular diseases. In one animal study, cigarette smoking decreased the overall angiogenesis effect of the soft tissue.<sup>37</sup> Nicotine use, regardless of the method, causes endovascular damages as well.<sup>38</sup> It is no wonder that any healthy person who smokes automatically becomes an American Society of Anesthesiologists category II patient. It is no surprise that most surgeons frown upon the smoking patient. Interestingly, in one study, no correlation has been seen with smoking and postoperative complications when breast surgeries are involved.<sup>7</sup> In another study, the higher the estimated overall cigarettes smoked until surgery and the number of pack years, the greater the association with infections.<sup>39</sup> One of the largest studies conducted of all research on smoking cessation and postoperative complications reveals a clear benefit and no increased complications from short-term smoking cessation; however, the exact ideal time for maximum benefit could not be determined.<sup>40</sup> Given these conflicting results, we nevertheless recommend that patients discontinue smoking immediately, but at least 2 weeks before the operation and 2 weeks after the operation.

### *Increasing Age*

Independently, increasing age has been clearly associated with increased complications of breast reduction/mastopexy surgery. Increased infection, wound healing complications, and need for debridement have been linked to decreasing hormone levels in women beginning at age 40 and more markedly over age 50 years.<sup>41</sup>

### **Preoperative Planning**

In order to reduce complications and achieve the most ideal outcome from surgery, flap design is done

to achieve the most robust blood supply. Density of breast tissue, sternal notch to nipple distance, presence of previous surgical scars, medications, and smoking history will influence this decision. As a basic tenant of surgery, the base of the pedicle should be at least twice the width of the NAC; if our NAC is 4 cm in diameter, the base of our flap is 8 cm or greater. Based upon the evidence reviewed for this article, the superior or medial superior pedicle would generally be our first choice to reduce complications in patients with breast length up to 35 cm.<sup>42-45</sup> With NAC longer than 35 cm or in small breasts with extremely dense breast tissue, our choice would be a medial or inferior pedicle followed by consideration for a free nipple graft in cases of severe gigantomastia.<sup>46</sup>

### Diagnosis

It is often challenging to differentiate intraoperatively whether a discolored NAC is a simple variation in native pigmentation, a response to tumescent infiltration, the result of arterial insufficiency, or venous insufficiency (congestion). Observation of skin color, capillary refill tests, and dermal bleeding remain the benchmark, but the search for more objective monitoring methods continues.<sup>47</sup> Arterial insufficiency will typically result in a gray or ash-colored areolar region. The capillary refill test performed on the NAC will typically be greater than 2.0 seconds in reperfusion. A pinprick test will result in dark or desaturated blood extrusion from the punctured epithelium. The NAC with venous insufficiency typically will have a deeply dark bluish complexion—a capillary refill test is generally very brisk, and a pinprick test will reveal rapid bleeding. Arterial flow will continue to worsen the venous congestion and over time will result in worsening of the edema and vascular congestion.

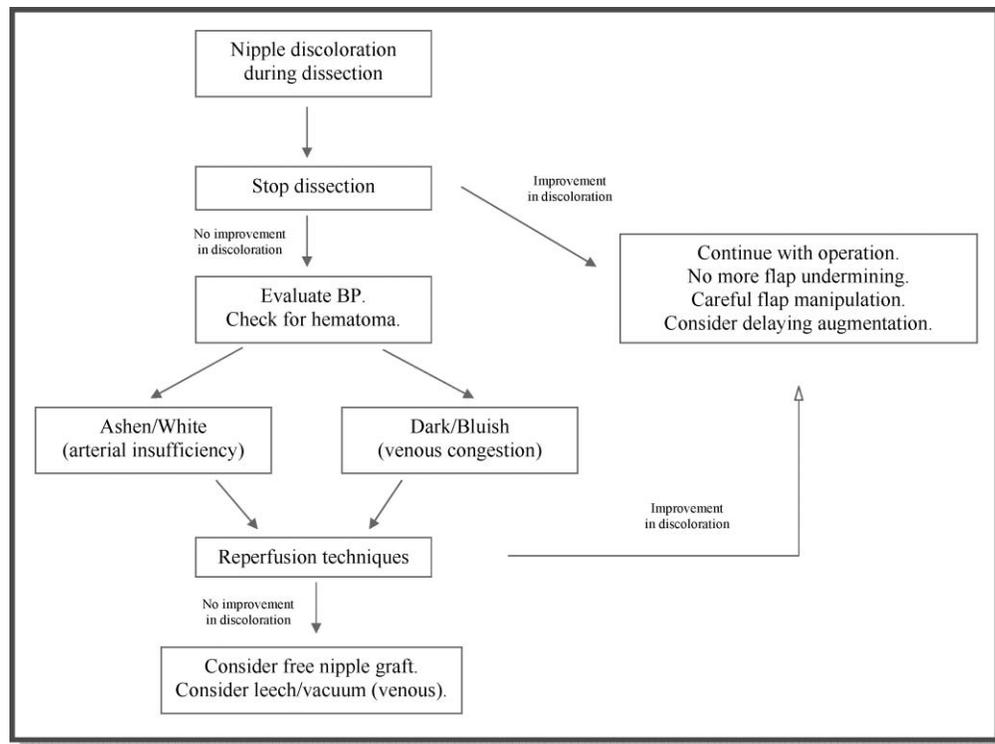
When extrapolating research information from free flap surgery, it is clear that the amount of time that elapses from the time of thrombosis to its correction is directly related to salvage rates. The overall salvage rates for free flaps due to anastomotic thromboses are 50% or greater.<sup>48-50</sup> Current objective diagnostic options include internal and external thermometry, laser Doppler flowmetry, internal and external Doppler monitoring, quantitative fluorescein fluorescence, pulse oximetry, and transcutaneous oxygen monitoring. The most popular of these methods are external Doppler monitoring, implantable Doppler monitoring, and assessment of cutaneous blood flow using laser Doppler flowmetry.<sup>51,52</sup> The external Doppler and implantable Doppler provides

advantages and disadvantages with variable sensitivity and specificity, but access generally limits its utility for cosmetic surgeons. Laser Doppler flowmetry may be the ideal instrument in a cosmetic office, but it cannot determine tissue perfusion and cannot objectively detect deterioration in flow. Ideally, a monitor should identify hemodynamic deterioration so as to allow for intervention and improved outcomes.<sup>51,53</sup>

Tissue oximetry holds great promise and is currently being evaluated in larger studies and may eventually lead to a shift in the standard of care in areolar perfusion monitoring. Near-infrared spectroscopy additionally leads the way in providing a consistent objective method of evaluation and reduces associated costs.<sup>53,54</sup> As most breast-related cases are elective and non-insurance-based procedures, these perfusion monitors remain economically impractical for cosmetic applications. Flap monitoring through the means of clinical skin color changes, capillary refill, and dermal bleeding remains the benchmark.<sup>50</sup>

### Management of Vascular Compromise

If intraoperative ischemia is visually obvious, the areola will likely be pale with delayed capillary refill, or tension will exist in excess of venous capillary outflow pressure. Immediate identification and response will theoretically result in reduced ischemia and an improved outcome (Figures 2 and 3). The most commonly recommended reperfusion maneuvers include: release of sutures, evacuation of hematoma if present, warm water irrigation, removal of implant prosthesis if it exists, and consideration for delayed closure (Table 2). The rotated pedicle must be reevaluated for kinking or flexure into excessive angles resulting in loss of inflow or outflow to the NAC. Kinking may be alleviated through additional breast parenchyma reduction or further undermining of the surrounding tissue, but keeping in mind that compromise in vascularity may result if the surgeon is overzealous. If the NAC returns to normal color, one may proceed with closure of the breast. If these maneuvers do not result in increased perfusion, arterial insufficiency or injury may be the cause. Consideration should be made for immediate free nipple grafting to the proposed inset site. Supplemental application of nitroglycerin paste to the affected areolar skin may improve venous outflow and should be considered where not contraindicated. Topical nitroglycerin causes a 2- to 5-fold increase in transcutaneous partial pressure of oxygen in skin up to 9 cm away from the site of application of the ointment



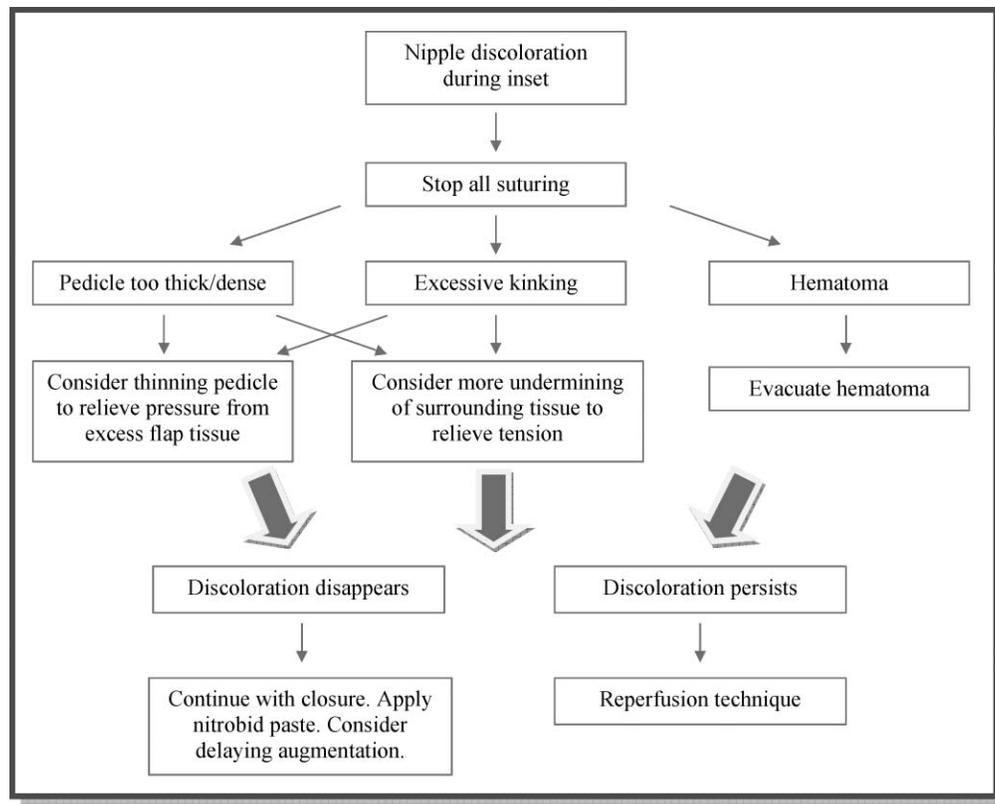
**Figure 2.** Algorithm for management of discoloration of nipple areolar complex during flap design.

and also dilates venous diameter in multiple other surgical applications.<sup>55,56</sup> Although without verified proof of improved outcomes in cases of areolar ischemia, hyperbaric oxygen has been advocated based upon extrapolated data from trauma and reconstructive literature and is routinely paid for by insurance carriers as indicated for a failed flap reconstruction. Recent experimental evidence confirms improved random pattern flap survival with early and frequent hyperbaric treatment.<sup>57</sup> Consultation with a director of hyperbaric medicine may be a consideration as adjunctive to improve outcomes.

The NAC with venous insufficiency typically will have a violaceous hue. A capillary refill test is generally very brisk. A pinprick test will reveal rapid bleeding. Arterial flow will continue to worsen the venous congestion and over time will result in edema of the NAC. The aforementioned treatments for dealing with arterial insufficiency will also apply for venous congestion. Leeches have been used since the 1960s and are proven to be an effective means of improving the outcomes for flap survival,<sup>58</sup> but they may not be a practical consideration in elective surgery venues. Various vacuum-assisted devices have also been shown to decrease venous congestion with measurable results.<sup>59</sup>

If there is evidence of ischemia during the intraoperative or postoperative phase, thoughtful consideration should be given to performing reperfusion maneuvers including the release of the periareolar closure, evacuation of any hematoma, release of tension or a kinked pedicle of the flap, warm sterile saline irrigation, and removal of any implant prosthesis and delayed closure of the opened wound may be necessary if reperfusion is not immediate and profound (Figure 4). The consideration and discussion of optional patient treatment must also be documented. Discussion with the patient should include the fact that there is no evidence of these techniques contributing to salvage and that these maneuvers could theoretically cause more harm to the already tenuous blood supply. If these maneuvers do not improve the discoloration of the NAC, free tissue nipple graft, which may sometimes have satisfactory results, should also be considered.<sup>60-63</sup>

Documentation immediately prior to discharge of viability and relevant positive and negative findings is also recommended. Twenty-four hour per day availability must be provided to the patients with questions or concerns regarding their care. A definitive protocol of postoperative evaluation must be established and



**Figure 3.** Algorithm for management of discoloration of nipple areolar complex during flap inset.

documented. Many states have declared through medical board recommendation that mandatory 24-hour, 1-week, 2-week, 1-month, 3-month, 6-month, and annual patient contacts will minimize patient abandonment accusations. Options include contact in person, and via e-mail, text message, or phone. Our recommendation is for a mandatory 24-hour examination in the office. Clear documentation must include the positive and negative findings. Coloration of the tissue and surrounding skin, reperfusion checks, amount of tension at the suture line, presence or

absence of hematoma, drainage, severity of edema, and pain score must be noted. An omission of documentation could be construed as evidence of absence of thought or proper evaluation, or as evidence for intervention.

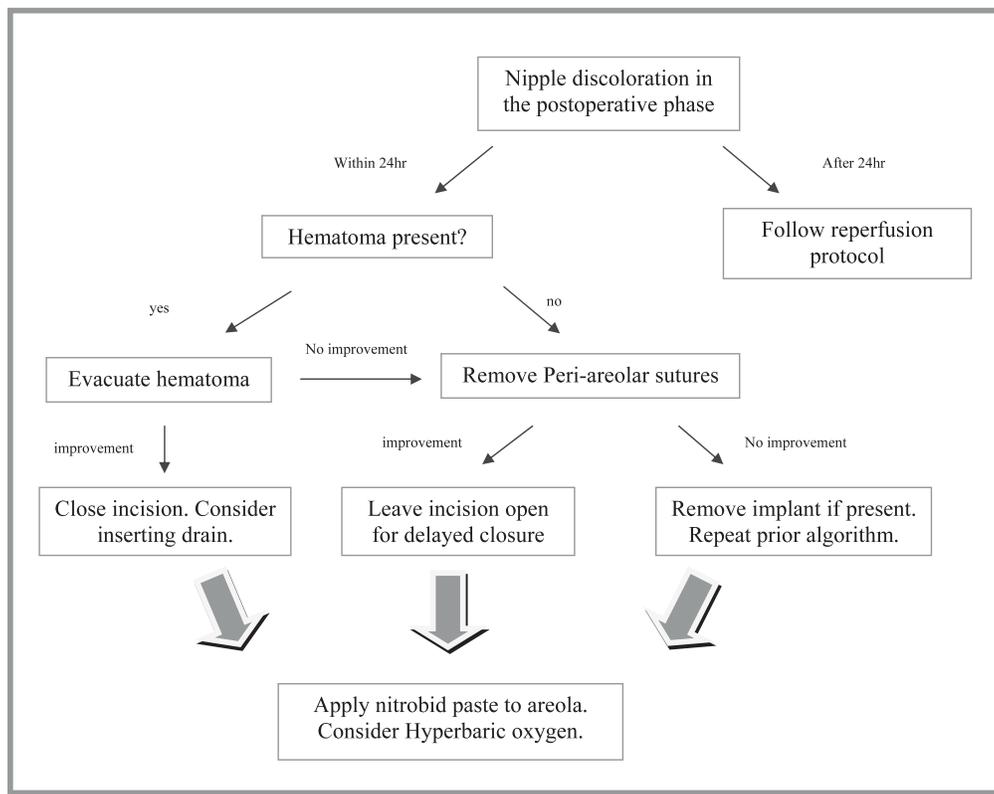
### Management of Epidermolysis

As previously mentioned, if transient ischemia occurs, epidermolysis may result in as many as 5–11% of surgeries performed. Blister-like formation may result from intradermal or subdermal edema. Epidermolysis generally happens at the periphery of the NAC where the newly reconstructed breast tissue joins the NAC pedicle. Edema and the subcutaneous tensile forces from deep sutures at the NAC periphery contribute to the formation of epidermolysis (Figure 5).

Wound care management comes in 3 main forms: mechanical, enzymatic, and surgical.<sup>64</sup> Generally, local wound measures is all that is needed to treat small epidermolysis. A topical wound care protocol should include a topical silver ion impregnated dressing or cream such as Silvadene 1%.<sup>65</sup> Applied twice per day, this will provide an environment for reduced bacterial

**Table 2. Reperfusion Techniques**

1. Release of sutures
2. Relief of excessive kink/flexure of the pedicle
3. Evacuation of hematoma, if present
4. Warm water irrigation
5. Removal of implant prosthesis, if present
6. Application of Nitro-Bid to areola
7. Leech therapy
8. Vacuum therapy
9. Cautious elevation of blood pressure



**Figure 4.** Algorithm for management of discoloration of nipple areolar complex during the postoperative phase.

contamination and promotion of reepithelialization. Nonviable surrounding parenchyma must also be debrided using mechanical means.<sup>66</sup> A novel use of transcutaneous electrical nerve stimulation has been applied to necrotic breast tissue and other superficial

skin wounds to increase blood flow and decrease the overall size of initial necrosis.<sup>67-69</sup>

Because the entire breast complex is well vascularized via the many arterial sources, superficial and deep breast wounds generally heal very well with standard packing of deep wounds with wet-to-dry dressings



**Figure 5.** Partial areolar necrosis.



**Figure 6.** Complete bilateral areolar necrosis. This is a photograph several days after mastopexy with simultaneous breast augmentation. We used bilateral medially based nipple areolar complex pedicle. Patient had a suprasternal notch to nipple distance greater than 30 cm preoperatively.



**Figure 7.** (a) Complete areolar necrosis. Simultaneous mastopexy with breast augmentation. Medially based nipple areolar complex (NAC) pedicle. (b) Same patient several days after debridement and full-thickness skin graft from thigh area. (c) Same patient 2 months after full-thickness skin graft. (d) Same patient 6 months after full-thickness skin graft. Note the clear demarcation of the prior areolar and nonareolar junction. (e) Different patient. This patient's healing was also complicated with full necrosis of bilateral NAC. She had received debridement with full-thickness skin graft from the thigh area. Additionally, she received tattooing of her NAC area.

twice daily. Autolytic agents such as Iruxol N (Santyl), Panafil, or collagenase may also provide additional chemical assistance in debridement when applied and dressing changed twice per day.<sup>70,71</sup> After debridement of all necrotic tissue, a protease modulating matrix, such as Promogran Matrix, may be recommended to speed the granulation of the affected area more rapidly than wet-to-dry dressings alone. Hydrogel and alginate dressings may also provide a moist environment and expedite healing.

Evidence exists that conservative management of full-thickness loss may result in excellent cosmesis without the need for further reconstructive offerings.<sup>23</sup> Certainly, bulk areas of necrotic tissue will necessitate debridement and placement on an empiric antibiotic until culture results dictate specific modification. Once the area is healed, the area can then be reassessed for possible local scar revision.

### Management of Complete Loss of the Areolar Complex

As previously described, complete necrosis occurs at a rate of 0.5–7.3% in breast reduction or lift surgery despite reperfusion interventions (Figures 6 and 7). Local mechanical debridement measures should be used to remove the necrotic debris entirely. There is an elevated risk of infection with any full-thickness loss, and antibiotics may be appropriate until primary closure is achieved. Once the site is “clean” and devoid of any nonviable tissue, local wound care treatments can then be started. Primary closure of the site is possible but requires a smaller wound and enough surrounding epidermis for coverage without causing considerable distortion. Conservative wound management can result in excellent cosmesis.<sup>72</sup> “Wet-to-dry” dressings are perhaps the oldest form of wound management that can aid in wound closure.<sup>72</sup> A recent revolution in “moist



**Figure 8.** (a) Creating a sub-nipple areolar complex pocket for areolar implant. (b) Areolar implant.

wound dressing,” using various enzymatics such as proteolytics and moist occlusive dressings, has shown wound closure can be achieved faster, with less scar tissue, and with less overall patient discomfort.<sup>73-75</sup>

Wound vacuums have been shown to reduce the size of the defect and heal the wound much faster than wet-to-dry dressings alone.<sup>76</sup> Wound vacuum dressings have also been shown to reduce local infection rates through relative anoxia and to reduce the size of the defect more rapidly and handle excess exudate more easily than dressings alone.<sup>75,76</sup> Special attention should be given to patients with deep defects that are difficult to pack and wounds that are greater than 4.0 cm in diameter. It should also be given to patients who are at increased risk for infection (eg, patients with diabetes or patients on immune modulating medications), are unable to care for the wound themselves, or have psychological problems. Consultation with a local wound

care facility and physician may be best for the most up-to-date techniques or patient convenience. Most wound care treatments are compensated by insurance.

### Areolar Reconstructive Options

Commonly used techniques for correction of skin loss of the areola include: simple scar revision, variations of skate flaps,<sup>77</sup> bell flap,<sup>78</sup> double opposing tab flap,<sup>79</sup> star flap,<sup>79</sup> top-hat flap,<sup>80</sup> twin flap,<sup>81</sup> propeller flap, S flap,<sup>82</sup> rolled dermal-fat flap,<sup>83</sup> and autologous cartilage. The use of AlloDerm, SurgiMend, and filler injection to restore nipple projection has also been reported.<sup>84,85</sup> Areolar tattooing may benefit the patient by adding pigment to an area with altered pigment as a result of scarring or skin loss.<sup>86,87</sup> Nipple projection can be permanently improved with a silastic sombrero implant (AART Inc, Reno, NV) that can be inserted under local anesthesia (Figure 8). Skin grafts are commonly obtained from the contralateral areola or thigh-vulva area in order to provide similar pigmentation and thickness of skin (Figure 7b). Currently, it may be unjustifiable to impose the inherent surgical risk of performing skin graft procedures when satisfaction of equal or higher level can be achieved with tattooing.

### Conclusions

It is an irrefutable fact that the areolar complex is in jeopardy in performing breast reductions and breast lifts. Comprehensive knowledge of the risk factors that contribute to increased risk, early and accurate diagnosis, and treatment options to manage the inevitable are essential. The options for diagnosis and management are dynamic and will continue to improve with advancing technology and research.

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