OPEN

PRS GLOBAL OPEN

ORIGINAL ARTICLE

Breast

A Prospective Study of Immediate Breast Reconstruction with Laser-Assisted Indocyanine Green Angiography

Shayda J. Mirhaidari, MD*
Gregory M. Beddell, MD*
Marc V. Orlando, MD*
Michael G. Parker, MD*
John C. Pedersen, MD†
Douglas S. Wagner, MD*

Background: Complication rates following immediate breast reconstruction range from 4% to 60%. Mastectomy skin flap necrosis (MSFN) is often the sentinel event leading to secondary complications.

Methods: All patients undergoing immediate reconstruction were enrolled. Upon mastectomy completion, the surgeon visually interpreted the skin flaps, performed laser-assisted indocyanine green angiography (LAIGA), and intervened if needed. Patients were followed for 90 days, documenting skin necrosis, infection, seroma, hematoma, implant loss, and reoperation.

Results: There were 126 patients who had 206 immediate breast reconstructions. The complication rate was 22.3%. The incidence of MSFN was 14.1%. The reoperation rate was 8.7%. There was 1 necrosis-related implant loss. Postoperative surveys were completed on 193 breasts: 137 had visual and LAIGA interpretation of well or adequately perfused, resulting in 5.8% rate of necrosis, 2 reoperations, and no implant losses. Twenty breasts had visual and LAIGA interpretation of marginal or poor perfusion. Sixteen of these underwent intervention. The necrosis rate in this group was 35% with no implant losses. A third group with 26 breasts had adequate visual interpretation with marginal or poor perfusion on LAIGA. Ten breasts had no intervention, and 16 received intervention. The overall necrosis rate in this group was 42.3%, with 4 reoperations for necrosis and 1 implant loss.

Conclusions: LAIGA can more accurately predict complications from MSFN than surgeon assessment alone. When surgeon decision making is supplemented with LAIGA, it reduces the incidence of MSFN, infection, implant loss, and overall unexpected reoperation rate. LAIGA is a valuable adjunct for intraoperative decision making. *(Plast Reconstr Surg Glob Open 2018;6:e1774; doi: 10.1097/GOX.0000000000001774; Published online 6 September 2018.)*

INTRODUCTION

The annual incidence of breast cancer is expected to reach 247,000 cases by 2016.[1] Roughly 40% of women undergoing mastectomy for oncologic resection will elect to undergo subsequent breast reconstruction.[2–4] In 2015, there were more than 86,000 implant or tissue expander procedures performed, constituting the method most often selected for breast reconstruction in the United States.[5] Complication rates following mastectomy vary from 17% to 48%, with infection rates reported to be between 5% and 14%.[6–8] Complications following immediate breast reconstruction (IBR) have ranged from 4% to 60%.[9–15] These include mastectomy skin flap necrosis (MSFN), seroma, hematoma, infection, implant loss, reoperation, and reconstructive failure.

MSFN is often the sentinel event leading to infection, delayed tissue expansion, reoperation, and/or implant loss. Mastectomy followed by immediate implant-based reconstruction is associated with skin flap ischemia in nearly 20% of patients, leading to partial or full-thickness necrosis (FTN), and implant loss in 8–18%.[16,17] Seroma rates are 10–20%, and hematoma rates are 0–2%.[18,19] Infection is most

*From the *Plastic & Reconstructive Surgery, Summa Health System, Akron, Ohio; and †Plastic & Reconstructive Surgery, Akron General Medical Center, Akron, Ohio.*

Received for publication December 15, 2017; accepted March 13, 2018.

Presented at the American Society of Plastic Surgeons Annual Meeting, October 2015, Boston, Mass; Summa Post Graduate Day, May 2015, Akron, Ohio; and Ohio Valley Society of Plastic Surgeons, May 2015, Covington, Ky.

DOI: 10.1097/GOX.0000000000001774

Disclosure: *Dr. Wagner is a Speaker for LifeCell. The Article Processing Charge was paid for by the authors.*

strongly associated with the eventual removal of the tissue expander or implant.[20–22] Such complications are a source of significant morbidity and may lead to delay in oncologic therapies and/or reconstructive failure rates of 5–20%.[20]

Identification of poorly perfused skin flaps has relied primarily upon the surgeon's clinical assessment of markers of skin viability, namely: flap color, capillary refill, temperature, and dermal bleeding. Recognition of ischemia should lead to excision of potentially nonviable skin before breast reconstruction. Clinical judgment is not, however, the most reliable tool to determine adequate tissue perfusion.[23,24]

Methods have been developed to assist the surgeon in recognizing skin flap ischemia, including fluorescein dye angiography and laser-assisted indocyanine green angiography (LAIGA).[25–27] While fluorescein angiography dates back to the 1970s, LAIGA is a more recent adjunct in the evaluation of breast reconstruction.[27–31] LAIGA is a vascular imaging system that allows real-time assessment of tissue perfusion in the operative setting. The indocyanine green (ICG) is injected intravenously and binds to plasma proteins within the intravascular compartment. The fluorescence of the ICG dye is captured and recorded by the system's camera. It serves as an adjunct to the surgeon's visual assessment of flap perfusion and may guide the surgeon in excising nonviable tissue. ICG is safe, with a half-life of 3–5 minutes and can be used multiple times intraoperatively.[32] It has been shown to be a better predictor of MSFN than both fluorescein angiography and clinical judgment.[16]

The objective of this study was to assess prospectively acquired data and clinical outcomes following IBR after mastectomy using intraoperative LAIGA. The primary measured outcome was MSFN, including partial and FTN. Secondary measured outcomes included infection, seroma, hematoma, implant loss, and reoperation.

METHODS

This prospectively performed study was reviewed and approved by the institutional review board. Written informed consent was obtained from patients. The study was performed at 2 separate university-affiliated tertiary medical centers from January 2014 to January 2015. One hundred twenty-six consecutive patients underwent 206 mastectomies followed by IBR. The patients were assigned a case number with removal of all identifying data.

Patients underwent mastectomy by 1 of 13 general surgeons. IBR was performed as either a direct to implant (DTI) procedure, a tissue expander, or autologous reconstruction by 1 of 3 plastic surgeons. Acellular dermal matrix (ADM-Alloderm RTU: Perforated & Non-Perforated-Branchburg, N.J.) was used in every case of implant-based reconstruction. The skin was temporarily closed after placement of tissue expander or sizer. Expanders were inflated to surgeon's estimated desired postprocedure volume. Patients were then injected with 7.5 mg of ICG. After a 3-minute latency period, images of the MSFs were taken via the SPY Elite System (NOVADAQ, Bonita Springs, Fla.).

Based on these images and the surgeon's clinical judgment, the decision was made to excise additional skin, remove fluid from the expander, change the implant size, or not intervene. If re-excision or removal of volume was undertaken, a second dose of 7.5 mg ICG was administered with an additional 3-minute latency period to document removal of potentially ischemic areas. Once the surgeon was satisfied with the results, the reconstruction was completed.

Drains were used in all patients. All implant-based and tissue expander reconstructions received postoperative antibiotics until drains were removed. Autologous tissue reconstructions did not receive postoperative antibiotics.

A postprocedure survey was completed by the surgeon to document flap viability using their judgment in comparison to LAIGA. This survey recorded the surgeon's clinical assessment of the flaps as well perfused,[1] adequately perfused,[2] marginal,[3] or poorly perfused.[4] Corresponding absolute LAIGA values were interpreted as follows: > 30 (well perfused), 16–30 (adequately perfused), 10–15 (marginal), and < 10 (poorly perfused).

Patients were followed for 90 days to document complications that included necrosis (full versus partial thickness), seroma, hematoma, infection, or implant loss. FTN was defined as a loss of epidermis and dermis with exposure of subcutaneous fat, muscle, ADM, or implant. Partial-thickness necrosis (PTN) was defined as the loss of epidermis, partial dermal loss, and/or eschar formation that does not expose subcutaneous fat. Infection was defined as documented erythema, fever, abscess, or purulent drainage requiring treatment with antibiotics or surgical intervention, regardless of whether or not positive cultures were obtained. Seroma was defined as a fluid collection after drain removal with or without intervention to drain the fluid. A hematoma was defined as any collection of blood with or without intervention to drain the blood.

All statistical analysis was performed with SPSSv23.0 (IBM Corp, Armonk, N.Y.). Comparison between LAIGA outcomes to historical control outcomes was performed using Fischer's exact test. P values < 0.05 were considered statistically significant.

RESULTS

Results from the prospectively collected data were compared with the senior surgeon's experience of retrospectively collected data from 194 consecutive immediate reconstructions in the period immediately before the use of LAIGA. Patient demographics and variables were found to be similar between the 2 groups barring reconstruction method, mastectomy type, and use of ADM. The historical study cohort underwent more nipple-sacrificing than nipple-sparing procedures as well as more tissue expander than implant-based reconstructions. There were also fewer reconstructions using ADM (Table 1).

In the current study, 126 patients underwent 206 immediate reconstructions (46 unilateral, 80 bilateral). Patients had an average age of 51 years and average body mass index of 27 (Table 1). The indication for mastectomy was malignancy in 82 breasts. There were 145 nipple-sacrificing

Table 1. Demographics and Patient Characteristics

Demographics and Patient Characteristics LAIGA Versus Historical			
Variable/Statistic	LAIGA	Historical	P
Total patients	126	117	
Age (y)			
Mean (SD)	51.4 (11.99)	52.8 (12.17)	0.38
Minimum–maximum	21–77	23–75	
BMI (kg/m^2)			
Mean (SD)	27.0 (5.65)	26.4 (5.92)	0.39
Minimum–maximum	16.1–43.6	18.2–51.3	
Hypertensive, n (%)	30 (23.8)	24 (20.5)	0.54
Diabetic, n (%)	10 (7.9)	9 (7.7)	0.94
Smoker, n (%)	12 (9.5)	9 (7.7)	0.61

mastectomies and 61 nipple-sparing mastectomies. One hundred eighty-four breasts underwent TE/DTI reconstruction and 22 breasts underwent autologous reconstruction. There were 11 breasts that had previous radiation. All these breasts had autologous reconstruction (Table 2).

There were 60 total complications in 47 breasts (22.8%). The majority of breasts (n = 35, 17.5%) experienced only 1 complication. There were 18 breasts diagnosed with an infection (8.7%). There was a 14.1% (n = 29) rate of flap necrosis. Twenty-one breasts had PTN with 5 requiring reoperation. The remaining 8 breasts had FTN, and all required reoperation. The reoperation rate for ischemia was 6.3% (n = 13). Implant loss occurred in 4 (1.9%) breasts total, only 1 (0.5%) of which was associated with ischemia (Table 3).

In the historical group, a total of 194 breasts were reviewed with an MSFN rate of 19.6% (n = 38). Eighteen (9.3%) of theses breasts had PTN, and 20 (10.3%) had FTN. The infection rate for this subset of patients was 14.9% (n = 29). The reoperation rate for ischemia was 10.3% (n = 20) with an implant loss of 7.2% (n = 14) breasts. Implant loss related to necrosis was 4.2% (n = 8) of breasts (Table 3).

While the rate of MSFN in the LAGIA group was lower than the historical group (14.% versus 19.6%), this was not statistically significant (P = 0.14). The rate of FTN,

Table 2. Surgical Characteristics

Surgical Characteristics LAIGA Versus Historical			
Variable/Statistic	LAIGA	Historical	P
Total surgeries (Jan 2014 to July 2015)	206	194	
Bilateral breasts reconstructed	80	77	0.60
Unilateral breasts reconstructed	126	117	
Diagnosis, n (%)			0.60
Cancer	82 (39.8)	80 (40.6)	
BRCA	42 (20.4)	32 (16.5)	
Prophylaxis	82 (39.8)	82 (42.3)	
Mastectomy type			**< 0.001**
Nipple-sacrificing mastectomy	145	177	
Nipple-sparing mastectomy	61	17	
Reconstruction method			**< 0.001**
DTI	165	44	
TE	15	117	
Lat and TE/implant	4	6	
pTRAM	16	22	
Free tissue transfer	3	0	
Latissimus	3	5	
Radiation, n (%)	11 (5.4)	12 (6.2)	0.72
Matrix, n (%)	191 (92.7)	167 (86.1)	**0.03**

Table 3. Comparison of Surgical Outcomes of IBRs: Current Study Group with the Use LAIGA Versus the Historical Group without the Use of LAIGA

Surgical Outcomes LAIGA Versus Historical	LAIGA	Historical	P
Total surgeries	206	194	
Total complications	60	58	0.87
No. complications (per breast), n (%)	47 (22.8)	48 (24.7)	0.65
Total necrosis rate (PTN or FTN), n (%)	29 (14.1)	38 (19.6)	0.14
Partial-thickness necrosis, n (%)	21 (10.2)	18 (9.3)	0.76
Full-thickness necrosis, n (%)	8 (3.9)	20 (10.3)	0.01
Infection, n (%)	18 (8.7)	29 (14.9)	0.05
Seroma, n (%)	11 (5.3)	14 (7.2)	0.46
Hematoma, n (%)	2 (1.0)	0 (0)	0.50
Implant loss, n (%)	4 (1.9)	14 (7.2)	0.01
Implant loss related to necrosis, n (%)	1 (0.5)	8 (4.1)	0.02
Unexpected reoperation, n (%)	18 (8.7)	30 (15.5)	0.05
Necrosis-related reoperation, n (%)	13 (6.3)	20 (10.3)	0.15

P value calculated from comparison of LAIGA to historical control rates.
**P* value from comparison to historical control rates.

however, was statistically significantly lower in the LAIGA group (3.9%, n = 8) versus the historical control (10.3%, n = 20, P = 0.01; Table 3).

In the LAIGA group, the infection rate was significantly lower (8.7% versus 14.9%, P = 0.05). Implant loss and necrosis-related implant loss were also significantly lower than the historical group (P = 0.01 and P = 0.02, respectively). Necrosis-related reoperation rates were no different between the 2 groups (P = 0.15). The overall unexpected reoperation rate, however, was significantly lower in the LAIGA group (8.7% versus 15.5%, P = 0.05; Table 3).

Postoperative surveys were completed by the plastic surgeon on 193 breasts. Data were divided into 3 separate groups based on visual and LAIGA interpretation of flap viability. The first group consisted of 137 breasts in which both visual and LAIGA interpretation correlated with a well or adequately perfused flap. Of these, 135 breasts had no further intervention, and 2 breasts went on to have skin excised based on visual interpretation. Six breasts (4.4%) experienced PTN, none of which required reoperation. Two breasts (1.5%) experienced FTN, and both required reoperation. Seven breasts (5.1%) developed infection with 4 requiring reoperation. One of the infections was attributed to FTN. There were 6 breasts (4.4%) with seroma, 2 of which experienced implant loss. There were 2 implant losses weresecondary to infected seroma without evidence of ischemia. One breast (0.7%) had a hematoma that required reoperation within 12 hours of surgery. The overall reoperation rate in this group was 4.4% (n = 6; Table 4).

The second group consisted of 20 breasts demonstrating marginal or poor perfusion on both visual and LAIGA interpretation. In 5 of these breasts, all nipple-sparing mastectomies (NSM), no further intervention was undertaken. One breast experienced PTN and another experienced FTN in this subgroup. Six of the 20 breasts had additional skin resected, and 2 went on to develop PTN. Seven breasts had application of nitropaste resulting in 1 PTN and 2 FTN. A combination of nitropaste and skin excision was performed on 2 breasts, and neither developed further necrosis. The

Table 4. Surgical Outcomes Based on Visual and SPY Interpretations

	Visual (1/2), SPY (1/2), 137 Breasts, n (%)	Visual (3/4), SPY (3/4), 20 Breasts, n (%)	Visual (1/2), SPY (3/4), 26 Breasts, n (%)
Partial-thickness necrosis	6 (4.4)	4 (20)	8 (30.1)
Full-thickness necrosis	2 (1.5)	3 (15)	3 (11.5)
Infection	7 (5.1)	2 (10)	3 (11.5)
Seroma	6 (4.4)	0	2 (7.7)
Hematoma	1 (0.7)	0	0
Implant loss	2 (1.5)	0	1 (3.8)
Total reoperation	6 (4.4)	3 (15)	5 (19.2)
Necrosis-related reoperation	2 (1.5)	3 (15)	5 (19.2)

1, Well perfused; 2, adequately perfused; 3, marginally perfused; 4, poorly perfused.

total necrosis rate was 35%—4 PTN and 3 FTN with reoperation. The total reoperation rate was 15%. There were 2 infections, 1 with associated ischemia. There were no seromas, hematomas, or implant losses (Table 4).

The third group included 26 breasts in which the visual interpretation of a well/adequately perfused flap did not correlate with LAIGA's interpretation of a poor/marginally perfused flap. Ten breasts had no further intervention, 7 of which were NSMs. Three of these 10 developed PTN but did not require reoperation. Two breasts developed FTN, both in the same patient. This patient required reoperation and had necrosis of the MSFs, TRAM flaps, and abdominal donor site. The hypercoagulable work up was negative. Four of the 5 breasts that developed either PTN or FTN were NSMs (Table 4).

Conversely, there were 14 breasts that had skin excised. Four of these developed PTN but did not require reoperation. One breast developed FTN and required reoperation and experienced implant loss. This patient had an anaphylactic reaction to lymphazurin requiring pressor support. The ancillary staff also placed an ice pack on the breast in the recovery room. Finally, 2 breasts had nitropaste application, 1 with further skin excision and 1 without; neither developed necrosis. The overall necrosis rate in this group was 42.3% (n = 11) with a reoperation rate of 19.2% (n = 5). The infection rate was 11.5% (n = 3), and implant loss rate was 3.8% (n = 1; Table 4).

DISCUSSION

In the present series of patients, LAIGA was used to evaluate MSF perfusion in a variety of IBR procedures. The ability to accurately predict and prevent MSFN is of particular importance in the setting of implant-based reconstruction. MSFN is often the sentinel event leading to potential infections and implant loss. Before LAIGA, the surgeon relied solely on clinical judgment of tissue perfusion to the MSFs. LAIGA has been offered as an adjunct to clinical decision making in the setting of IBR. Upon identifying poorly perfused MSFs, the surgeon may excise additional skin, change the size of the implant, or deflate the tissue expander to remove tension on the mastectomy flap. With LAIGA, the overall necrosis rate was 14.1.%, comparing favorably to historical figures of 19.6% (P = 0.14). Patients experienced a necrosis-related reoperation rate of 6.3% and necrosis-related implant loss of 0.5%. Historical data revealed rates of 10.3% and 4.1%, respectively (P = 0.15, P = 0.02).

LAIGA-assisted IBR compared favorably with the author's historical rates of MSFN as well as with rates seen in the literature. Phillips et al.[16] published a series of 51 tissue expander-implant breast reconstructions in 32 patients to examine the ability to predict MSFN with LAIGA or conventional fluorescein dye angiography versus the gold standard of clinical judgment alone. The authors found that both LAIGA and fluorescein dye angiography

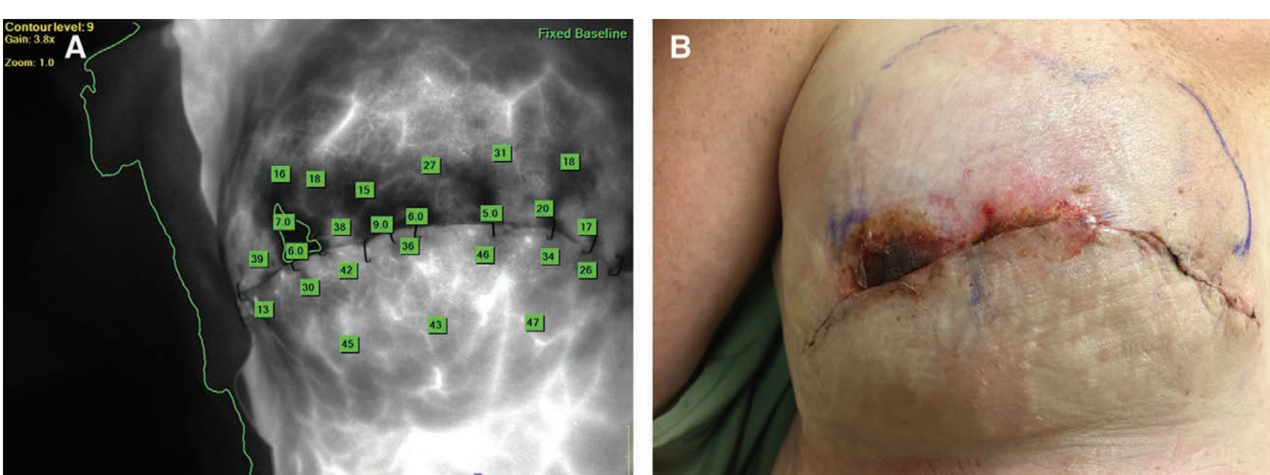

Fig. 1. A, Intraoperative LAIGA image of the right breast status postreconstruction in a nipple-sacrificing mastectomy. Absolute perfusion values predict poor/marginal perfusion. B, Postoperative photograph of the right breast after nipple-sacrificing mastectomy with DTI reconstruction in which skin resection was not performed with low perfusion values. The darkened area demonstrates the resulting FTN.

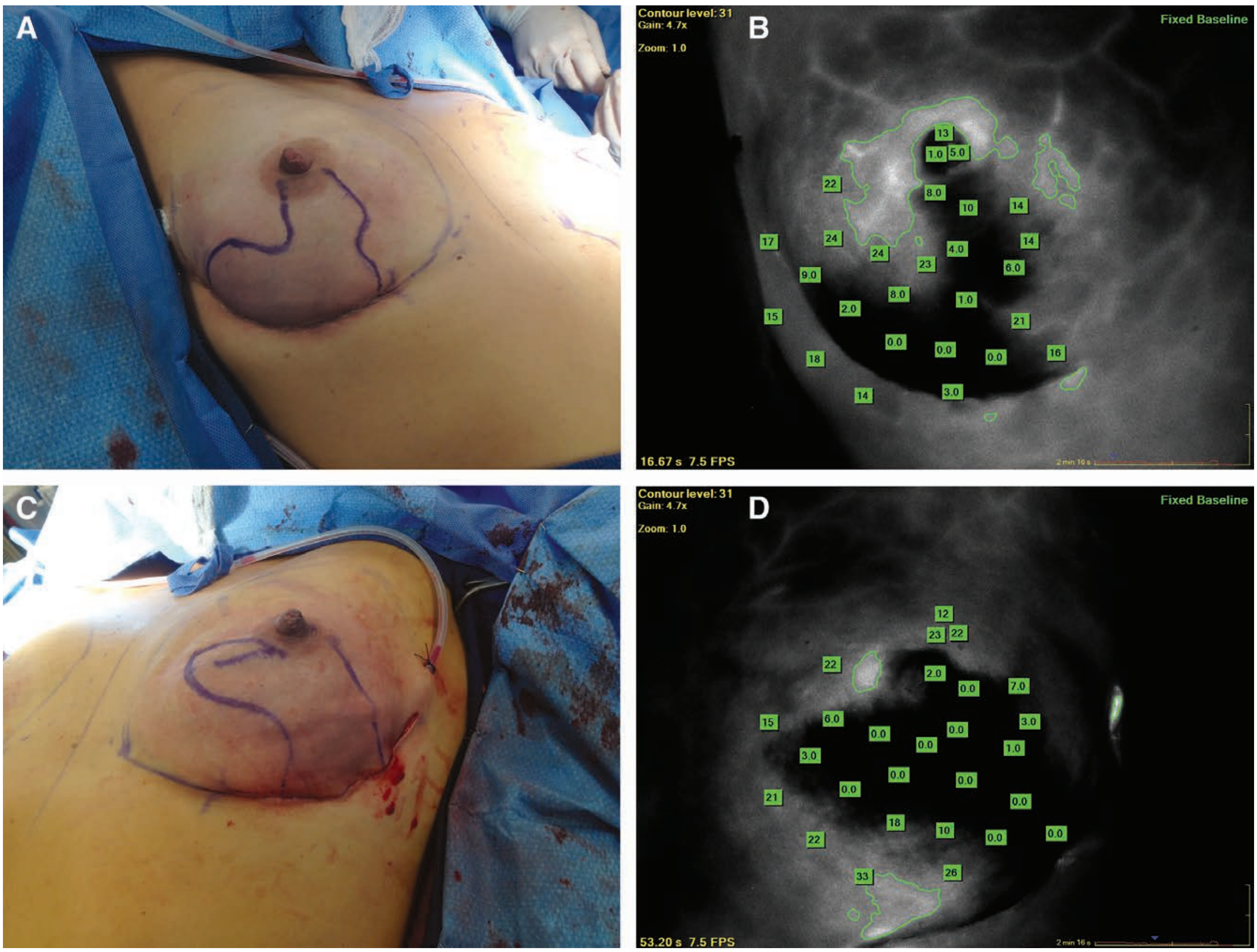

Fig. 2. A, Intraoperative photograph of the right breast status postreconstruction in an NSM. The area outlined by the purple marker indicates the area of ischemia as predicted by the LAIGA. B, Corresponding LAIGA image right breast. None of this skin was excised based on the type of mastectomy performed. C, Intraoperative photograph of left breast status postreconstruction in an NSM. Again is an area outlined by the purple marker indicating the area of ischemia as predicted by LAIGA. D, Corresponding LAIGA image left breast.

correctly predicted necrosis in 19 of 21 cases, where clinical judgment had failed. Both modalities over predicted extent of necrosis, but LAIGA was more specific and had higher accuracy. They also concluded their rates of overall MSFN, FTN, and PTN to be 41.2%, 11.8%, and 29.4%, respectively. These figures were higher than those seen in the present series (14.1%, 3.9%, and 10.2%).[16]

Munabi et al.[33] also published a series of 62 breast reconstructions using LAIGA. No interventions were performed based on these values; a similar rate of FTN (13%) was demonstrated. The study's aim was to determine what intraoperative perfusion values produced by LAIGA would predict MSFN. A value of < 7 was found to accurately predict the development of MSFN with a sensitivity of 88%.[33]

While the authors mentioned in the above studies used LAIGA, higher complication rates were still seen. It must be recognized that LAIGA in and of itself does not prevent complications. It is a tool that aids the clinician in performing interventions that are integral to preventing complications. The previous studies did not aim to intervene based on LAIGA interpretation, whereas as the current study allowed the clinician to intervene, thus resulting in lower complication rates.

As the groups were further divided, the real benefit of LAIGA was elucidated. In the setting that both surgeon and LAIGA were in concordance of a well/adequately perfused skin flap, the necrosis rate was only 5.8% (n = 8). This led to a necrosis-related reoperation rate of 1.5% (n = 2) with no implant loss secondary to FTN. When the surgeon and LAIGA both determined the flaps were marginally/poorly perfused, the necrosis rate was 35% (n = 7) with a reoperation rate of 15% (n = 3). In the third group, the surgeon felt the tissues were well/adequately perfused, but LAIGA revealed marginal/poor perfusion. This group had the highest necrosis rate of 42.3% (n = 11), with a necrosis-related reoperation rate of 11.5% (n = 3). One breast had an implant loss directly related to necrosis, resulting in an implant loss rate of 3.8%.

The highest necrosis rate was seen in the "discordant" group in which the surgeon felt the flap was well/adequately perfused, but the LAIGA demonstrated a marginal/poorly perfused flap. Although there were 16 breasts

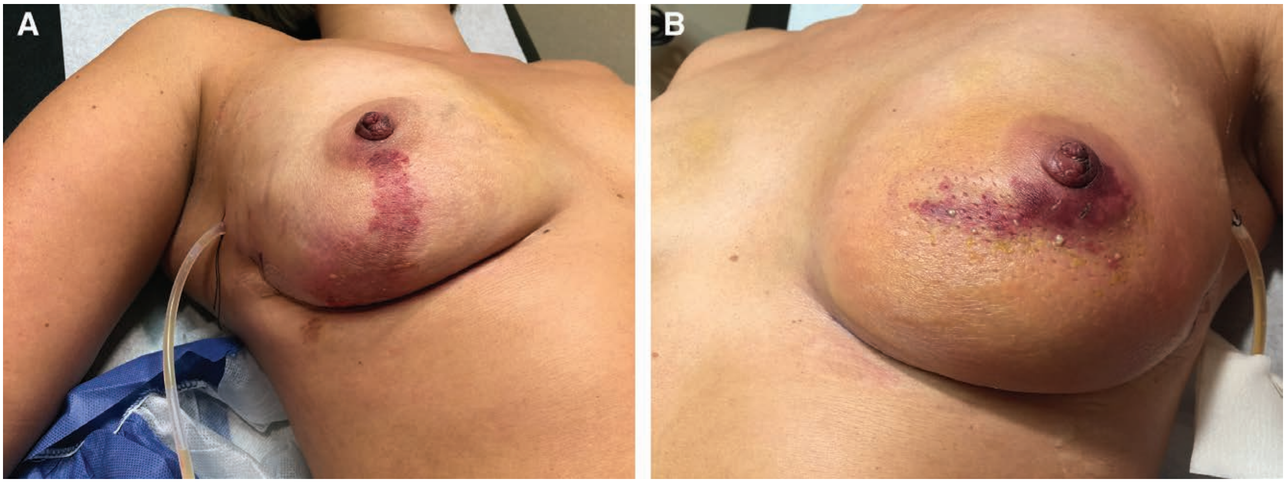

Fig. 3. The same patient-right and left breasts after NSM and reconstruction. Several weeks postoperatively, the breasts demonstrate corresponding areas of PTN.

that received intervention, there were still poor outcomes. There are 2 points of consideration. First, there were only 4 PTNs and 1 FTN in this subset of patients. Only 1 of the PTNs required reoperation, and there were no implant losses. There was 1 FTN, and this was in a patient who had developed an anaphylactic reaction to the lymphazurin given for SLNB. This patient required pressure support and also had an ice pack inadvertently placed in the recovery room. No intervention short of not receiving lymphazurin would have prevented this outcome. Second, the intervention rate must be compared with the intervention rate in the "bad/bad" group (surgeon and LAIGA predicted marginal/poor perfusion). The intervention rate was 80% (16/20) in the "bad/bad" group versus 61.5% (16/26) in the "discordant" group. While the surgeon intervened in both groups, it appears they intervened more aggressively in the "bad/bad" group, suggesting that he did not yet trust the LAIGA's measurements (Fig. 1).

In the 2 groups where LAIGA revealed marginal/poor perfusion (46 breasts), 15 breasts had no intervention. Eleven of these 15 breasts had undergone NSMs. The surgeons' rationale for electing not to intervene was based on the type of mastectomy performed in an effort to maintain the nipple-areolar complex (NAC). Resecting the area of ischemia in its entirety as indicated by LAIGA would result in loss of the NAC as well as a significant portion of the lower flap (Fig. 2). When no intervention was performed, the outcome at times resulted in PTN (Fig. 3). Conservative management resulted in good aesthetic outcome as demonstrated almost 2 years later (Fig. 4).

In these 11 NSMs in which no intervention was performed, there was an overall necrosis rate of 54.5% (6/11 breasts). The reoperation rate was 27.3% (3/11 breasts) due to FTN. Clearly, patients undergoing NSMs produce a bias for the surgeon not to intervene. Despite LAIGA data that suggested marginal/poor perfusion, additional skin was not excised, resulting in the highest subset of necrosis and reoperations. This may suggest a delayed procedure be considered in NSM.

As the study continued, surgeons were more likely to intervene on poorly perfused MSFs based on LAIGA. This implies a learning curve in trusting LAIGA. On 3 breasts in 2 patients, the perfusion was so poor by LAIGA that reconstruction was abandoned and additional skin re-

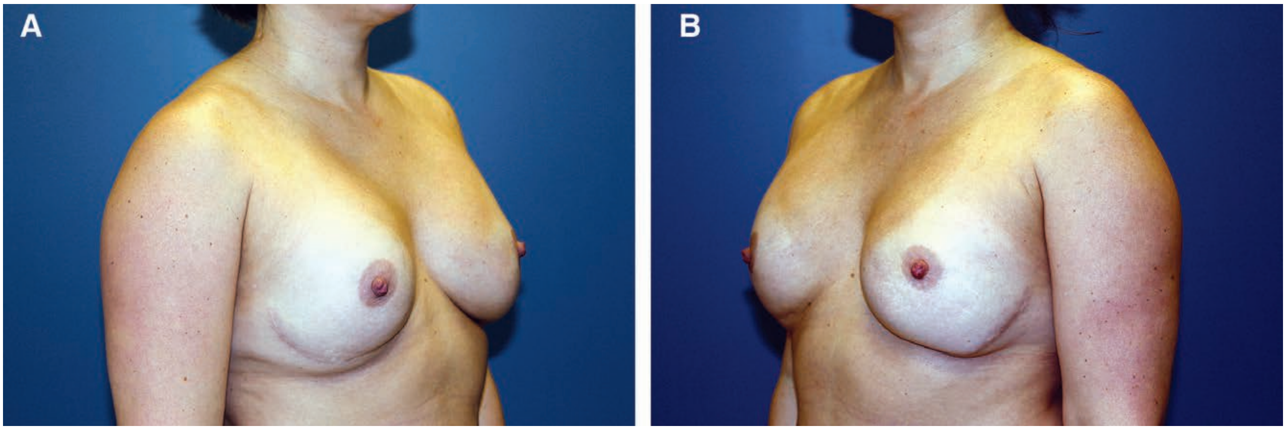

Fig. 4. The same patient after NSM and reconstruction approximately 2 years postoperatively. Evidence of previous ischemia to the NAC and lower flap not demonstrated.

sected before closing the mastectomy flaps primarily. Two of 3 breasts developed further necrosis but were excluded from the study as no reconstruction was done.

Several limitations are present in the current study. There was a potential lack of consistency between plastic surgeons during subjective analysis of MSF perfusion. There may have also been variability between surgeons when analyzing LAIGA results. The occasional use of topical nitroglycerin based on plastic surgeon preference was also an uncontrolled variable.

Finally, the patient demographics and variables were not completely matched cohorts. The historical group was found to have more TE reconstructions than the study group (117 versus 15—Table 2). The surgeons' practices have since evolved from performing TE-based reconstructions to implant-based reconstructions. It is felt that both TE and implant-based reconstruction fall into the prosthetic-based reconstruction category and exhibit similar surgical concerns when examining reconstruction outcomes. If anything, performing TE-based reconstruction in the historical cohort would have possibly allowed for lower rates of MSFN, given the surgeon's ability to deflate the TE with any intraoperative clinical concern for flap ischemia. There was also a statistically significant difference in the number of nipple-sparing mastectomies performed in the historical group (17 versus 61—Table 2). Again, the difference in mastectomy type performed appears to be a reflection of the breast surgeons' and authors' practice patterns during that time period. NSM has recently become a more widely accepted approach in both prophylactic mastectomy as well as therapeutic mastectomy as the oncologic criteria continue to be reexamined. The NSM presents a unique technical challenge to the plastic surgeon with employment of often smaller or more remote incisions and longer mastectomy skin flaps that risk MSFN.[34]

CONCLUSIONS

In 206 consecutive IBRs using LAIGA, a MSFN rate of 14.1% (n = 29) and full thickness necrosis rate of 3.9% (n = 8) occurred. This resulted in an unexpected necrosis-related reoperation rate of 6.3% (n = 13) with only 1 implant loss. These data compare favorably to previously published figures and our historical data. Use of LAIGA in IBR can reduce the incidence of FTN and implant loss by encouraging plastic surgeons to intervene more aggressively. LAIGA also offers a valuable adjunct to intraoperative clinical decision making regardless of the type of mastectomy performed.

Shayda Mirhaidari, MD
Plastic & Reconstructive Surgery Department
Summa Health System
Akron City Hospital
55 Arch St., Suite 2F
Akron, OH 44304
E-mail: mirhaidaris@summahealth.org

ACKNOWLEDGMENTS

The authors thank M. David Gothard for data analysis for clinical research studies.

REFERENCES

1. US Breast Cancer Statistics. 2016. Available at http://www.breastcancer.org/symptoms/understand_bc/statistics.
2. Morrow M, Li Y, Alderman AK, et al. Access to breast reconstruction after mastectomy and patient perspectives on reconstruction decision making. *JAMA Surg*. 2014;149:1015–1021.
3. Albornoz CR, Bach PB, Mehrara BJ, et al. A paradigm shift in U.S. breast reconstruction: increasing implant rates. *Plast Reconstr Surg*. 2013;131:15–23.
4. Bostwick J 3rd, Carlson GW. Reconstruction of the breast. *Surg Oncol Clin N Am*. 1997;6:71–89.
5. 2015 Plastic Surgery Statistics Report. 2017. Available at http://d2wirczt3b6wjm.cloudfront.net/News/Statistics/2015/plastic-surgery-statistics-full-report-205.pdf.
6. Aitken DR, Minton JP. Complications associated with mastectomy. *Surg Clin North Am*. 1983;63:1331–1352.
7. Feigenberg Z, Zer M, Dintsman M. Comparison of postoperative complications following radical and modified radical mastectomy. *World J Surg*. 1977;2:207–211.
8. Vinton AL, Traverso LW, Zehring RD. Immediate breast reconstruction following mastectomy is as safe as mastectomy alone. *Arch Surg*. 1990;125:1303–1307; discussion 1307.
9. Alderman AK, Wilkins EG, Kim HM, et al. Complications in postmastectomy breast reconstruction: two-year results of the Michigan Breast Reconstruction Outcome Study. *Plast Reconstr Surg*. 2002;109:2265–2274.
10. Salzberg CA, Ashikari AY, Koch RM, et al. An 8-year experience of direct-to-implant immediate breast reconstruction using human acellular dermal matrix (AlloDerm). *Plast Reconstr Surg*. 2011;127:514–524.
11. Garwood ER, Moore D, Ewing C, et al. Total skin-sparing mastectomy: complications and local recurrence rates in 2 cohorts of patients. *Ann Surg*. 2009;249:26–32.
12. Chun YS, Verma K, Rosen H, et al. Implant-based breast reconstruction using acellular dermal matrix and the risk of postoperative complications. *Plast Reconstr Surg*. 2010;125:429–436.
13. Antony AK, McCarthy CM, Cordeiro PG, et al. Acellular human dermis implantation in 153 immediate two-stage tissue expander breast reconstructions: determining the incidence and significant predictors of complications. *Plast Reconstr Surg*. 2010;125:1606–1614.
14. Colwell AS, Damjanovic B, Zahedi B, et al. Retrospective review of 331 consecutive immediate single-stage implant reconstructions with acellular dermal matrix: indications, complications, trends, and costs. *Plast Reconstr Surg*. 2011;128:1170–1178.
15. Sullivan SR, Fletcher DR, Isom CD, et al. True incidence of all complications following immediate and delayed breast reconstruction. *Plast Reconstr Surg*. 2008;122:19–28.
16. Phillips BT, Lanier ST, Conkling N, et al. Intraoperative perfusion techniques can accurately predict mastectomy skin flap necrosis in breast reconstruction: results of a prospective trial. *Plast Reconstr Surg*. 2012;129:778e–788e.
17. Woerdeman LA, Hage JJ, Smeulders MJ, et al. Skin-sparing mastectomy and immediate breast reconstruction by use of implants: an assessment of risk factors for complications and cancer control in 120 patients. *Plast Reconstr Surg*. 2006;118:321–330; discussion 331.
18. Slavin SA, Schnitt SJ, Duda RB, et al. Skin-sparing mastectomy and immediate reconstruction: oncologic risks and aesthetic results in patients with early-stage breast cancer. *Plast Reconstr Surg*. 1998;102:49–62.
19. Carlson GW, Losken A, Moore B, et al. Results of immediate breast reconstruction after skin-sparing mastectomy. *Ann Plast Surg*. 2001;46:222–228.
20. Jimenez-Puente A, Prieto-Lara E, Rueda-Dominguez A, et al. Complications in immediate breast reconstruction after mastectomy. *Int J Technol Assess Health Care*. 2011;27: 298–304.

21. Handel N, Cordray T, Gutierrez J, et al. A long-term study of outcomes, complications, and patient satisfaction with breast implants. *Plast Reconstr Surg*. 2006;117:757–767; discussion 768.
22. Armstrong RW, Berkowitz RL, Bolding F. Infection following breast reconstruction. *Ann Plast Surg*. 1989;23:284–288.
23. Mothes H, Dönicke T, Friedel R, et al. Indocyanine-green fluorescence video angiography used clinically to evaluate tissue perfusion in microsurgery. *J Trauma*. 2004;57:1018–1024.
24. Olivier WA, Hazen A, Levine JP, et al. Reliable assessment of skin flap viability using orthogonal polarization imaging. *Plast Reconstr Surg*. 2003;112:547–555.
25. Singer R, Lewis CM, Franklin JD, et al. Fluorescein test for prediction of flap viability during breast reconstructions. *Plast Reconstr Surg*. 1978;61:371–375.
26. Losken A, Styblo TM, Schaefer TG, et al. The use of fluorescein dye as a predictor of mastectomy skin flap viability following autologous tissue reconstruction. *Ann Plast Surg*. 2008;61:24–29.
27. Komorowska-Timek E, Gurtner GC. Intraoperative perfusion mapping with laser-assisted indocyanine green imaging can predict and prevent complications in immediate breast reconstruction. *Plast Reconstr Surg*. 2010;125:1065–1073.
28. Newman MI, Samson MC. The application of laser-assisted indocyanine green fluorescent dye angiography in microsurgical breast reconstruction. *J Reconstr Microsurg*. 2009;25:21–26.
29. Newman MI, Samson MC, Tamburrino JF, et al. Intraoperative laser-assisted indocyanine green angiography for the evaluation of mastectomy flaps in immediate breast reconstruction. *J Reconstr Microsurg*. 2010;26:487–492.
30. Pestana IA, Coan B, Erdmann D, et al. Early experience with fluorescent angiography in free-tissue transfer reconstruction. *Plast Reconstr Surg*. 2009;123:1239–1244.
31. Moyer HR, Losken A. Predicting mastectomy skin flap necrosis with indocyanine green angiography: the gray area defined. *Plast Reconstr Surg*. 2012;129:1043–1048.
32. Gurtner GC, Jones GE, Neligan PC, et al. Intraoperative laser angiography using the SPY system: review of the literature and recommendations for use. *Ann Surg Innov Res*. 2013;7:1.
33. Munabi NC, Olorunnipa OB, Goltsman D, et al. The ability of intra-operative perfusion mapping with laser-assisted indocyanine green angiography to predict mastectomy flap necrosis in breast reconstruction: a prospective trial. *J Plast Reconstr Aesthet Surg*. 2014;67:449–455.
34. Spear SL, Hannan CM, Willey SC, et al. Nipple-sparing mastectomy. *Plast Reconstr Surg*. 2009;123:1665–1673.