Intraoperative Perfusion Techniques Can Accurately Predict Mastectomy Skin Flap Necrosis in Breast Reconstruction: Results of a Prospective Trial

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ABSTRACT:

Background: Intraoperative vascular imaging can assist assessment of mastectomy skin flap perfusion to predict areas of necrosis. No head-to-head study has compared modalities such as laser-assisted indocyanine green dye angiography and fluorescein dye angiography with clinical assessment.

Methods: The authors conducted a prospective clinical trial of tissue expander–implant breast reconstruction with intraoperative evaluation of mastectomy skin flaps by clinical assessment, laser-assisted indocyanine green dye angiography, and fluorescein dye angiography. Intraoperatively predicted regions of necrosis were photographically documented, and clinical assessment guided excision. Postoperative necrosis was directly compared with each prediction. The primary outcome was all-inclusive skin necrosis.

Results: Fifty-one tissue expander–implant breast reconstructions (32 patients) were completed, with 21 cases of all-inclusive necrosis (41.2 percent). Laser-assisted indocyanine green dye angiography and fluorescein dye angiography correctly predicted necrosis in 19 of 21 of cases where clinical judgment had failed. Only six of 21 cases were full-thickness necrosis, and five of 21 required an intervention (9.8%). Risk factors such as smoking, obesity, and breast weight greater than 1000 g were statistically significant. Laser-assisted indocyanine green dye angiography and fluorescein dye angiography overpredicted areas of necrosis by 72 percent and 88 percent (p=0.002). Quantitative analysis for laser-assisted indocyanine green dye angiography in necrotic regions showed absolute perfusion units less than 3.7, with 90% sensitivity and 100% specificity.

Conclusions: Laser-assisted indocyanine green dye angiography is a better predictor of mastectomy skin flap necrosis than fluorescein dye angiography and clinical judgment. Both methods overpredict without quantitative analysis. Laser-assisted indocyanine green dye angiography is more specific and correlates better with the criterion standard diagnosis of necrosis.

KEY POINTS:

1. A prospective clinical trial designed to compare clinical assessment, fluorescein dye angiography, and laser-assisted indocyanine green dye (SPY) angiography to predict mastectomy skin flap necrosis in tissue expander–implant breast reconstruction.
    a. A total of 51 implant breast reconstructions were performed in 32 patients.
2. Predictive accuracy was calculated by comparing the area of predicted necrosis to the actual areas of necrosis.
    a. Analysis was performed using each breast as a measurable unit, and all three modalities were compared on the same breast.
    b. Standard for diagnosis of necrosis was intraoperative clinical observation of ischemia with skin removal or postoperative assessment of necrosis within 4 weeks.
3. There were 21 cases of all-inclusive necrosis (15 patients), representing a 41.2% total necrosis rate.
    a. Of these, the majority consisted of partial-thickness necrosis that did not require operative intervention.
    b. Only five breasts (9.8%) in four patients resulted in full-thickness necrosis of sufficient area to require operative intervention, either debridement or removal of the implant.
4. SPY angiography and fluorescein dye angiography both correctly predicted the occurrence of necrosis in 19 of 21 of cases (sensitivity, 90%), although SPY angiography had a higher specificity.
    a. Of the 30 breasts in which necrosis did not occur, SPY angiography predicted no necrosis in 15, whereas fluorescein dye angiography predicted no necrosis in 9.

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5. SPY angiography has almost three times the predictive accuracy of fluorescein dye angiography in terms of preserving viable tissue.
    a. In addition, the McNemar test revealed that SPY angiography predictions were more concordant with criterion standard for diagnosis of necrosis than fluorescein dye angiography (p =0.031).
6. The SPY-Q analysis toolkit reports a quantitative value of perfusion based on the intensity of fluorescence within the tissue.
    a. This value can be provided as a percentage (relative perfusion units) when compared with other healthy tissue within the field or as absolute perfusion units value based on 255 shades of gray.
7. Although a multitude of factors contribute to mastectomy skin flap necrosis, the persistently high rate of necrosis reflects the limitations of clinical judgment alone and highlights the need for new reliable tools.
8. In this study, clinical excision was performed in nine breasts based on surgeon intraoperative assessment, and a majority (78%) of these cases still resulted in necrosis.
    a. Clinical assessment resulted in failure of gross detection and underprediction of ischemia and necrosis.
9. Any potential decrease in the rates of necrosis with the use of technological aids would yield a substantial benefit in decreasing morbidity and costs while improving reconstructive outcomes and patient satisfaction.
10. Although fluorescein dye angiography and SPY angiography have similar sensitivities, SPY angiography is significantly more accurate in identifying areas of potential necrosis without inclusion of viable skin.
    a. Furthermore, use of quantitative imaging with SPY-Q analysis can further refine predictions, allowing a high degree of sensitivity and specificity.

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