Clinical Practice Review

Optimizing perioperative outcomes in autologous breast reconstruction

Robert G. DeVito^, Lindsey Craft, Christopher A. Campbell, John T. Stranix^

Department of Plastic Surgery, University of Virginia Health System, Charlottesville, Virginia, USA

Contributions: (I) Conception and design: CA Campbell, JT Stranix; (II) Administrative support: L Craft, JT Stranix; (III) Provision of study materials or patients: RG DeVito, L Craft; (IV) Collection and assembly of data: RG DeVito, JT Stranix; (V) Data analysis and interpretation: RG DeVito, JT Stranix; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: John T. Stranix, MD. West Complex 4th Floor, 1300 Jefferson Park Avenue, Department of Plastic Surgery, Charlottesville, VA, USA. Email: jts3v@virginia.edu.

Abstract: Perioperative optimization in surgery is paramount to the success of an operation. This especially applies to autologous breast reconstruction where small details can make the difference between success and failure. In this article, the authors discuss a wide array of aspects of perioperative care in autologous reconstruction and best practices. Stratification of surgical candidates, including types of autologous breast reconstruction are discussed. The informed consent process, including benefits, alternatives, and risks specific to autologous breast reconstruction is delineated. The importance of operative efficiency and benefits of pre-operative imaging are discussed. The importance and benefits of patient education is examined. Also examined at length are pre-habilitation and its effects on patient recovery, antibiotic prophylaxis including duration and organism coverage, venous thromboembolism risk stratification and prophylaxis, anesthetic and analgesic interventions including multiple types of regional blocks are broken down. Flap monitoring methods and the importance of clinical exam are emphasized, and the potential risks of blood transfusion in free flap patients are examined. Post-operative interventions and determining readiness for discharge are also reviewed. The review of these components of perioperative care allows the reader to gain comprehensive insight into autologous breast reconstruction best practices and the important role perioperative care plays in this patient population.

Keywords: Breast reconstruction; enhanced recovery after surgery (ERAS); deep inferior epigastric artery perforator (DIEP); perioperative; autologous

Submitted Oct 17, 2022. Accepted for publication Mar 23, 2023. Published online Apr 10, 2023.
doi: 10.21037/gs-22-608
View this article at: https://dx.doi.org/10.21037/gs-22-608

Introduction

Surgical care is not limited to the operating room. It has been proven that the care provided both before and after surgery affects outcomes in surgery (1). Providing quality perioperative care is an essential component of surgical intervention in plastic surgery. Particular attention to this fact has been paid regarding breast reconstruction patients over the last twenty years. These interventions have come to form in the shape of enhanced recovery after surgery (ERAS) pathways which pay particular attention to pre-operative, intra-operative, and post-operative interventions that optimize patient care by reducing post-operative pain, decreasing opioid usage, shortening length of stay, and increasing mobility post-operatively (2). The Enhanced Recovery After Surgery Society publishes consensus guidelines to assist clinicians in shortening recovery times

^ ORCID: John T. Stranix, 0000-0002-9770-6127; Robert G. DeVito, 0000-0002-7301-0424.

for their patients. ERAS pathways are not limited to tertiary care centers and have also been applied with success in the private practice setting (3).

History

The emphasis on the importance of perioperative care in the clinical pathway of plastic surgery has been relatively recent in the history of the specialty. A PubMed database query for "enhanced recovery after surgery plastic surgery" yields 66 results in the years 1994–2017 and 143 results from 2018-present day demonstrating increased utilization and awareness of the benefits in plastic surgery patient populations (4). It also shows attempts to improve and standardize these pathways and protocols for plastic surgery patients (5). The origins of ERAS come from Europe when clinicians and researchers worked in the late 1990's and 2000's to begin collaborative study on perioperative care. Progression from there included evidence-based consensus protocols for patients undergoing colonic surgery in 2005, which progressed to evidence-based guidelines in urologic patients, gynecologic patients, lung, cardiac, and more patient populations. The first ERAS Society guidelines in plastic surgery were published in 2017, providing guidance on optimal perioperative care in breast reconstruction patients (1,6).

Stratifying candidates for autologous breast reconstruction

Optimizing the perioperative care of a patient starts in the pre-operative setting with patient selection. Autologous breast reconstruction indications are surgeon dependent and tailored to the individual patient's preference, history, and relevant anatomy. Breast volume and shape, body habitus, donor site considerations, prior surgery, oncologic treatments, and medical co-morbidities should all be considered in a holistic fashion. It is well understood that the rate of obesity in the United States has increased over the last several decades. This has affected perioperative considerations in breast reconstruction in two major ways. The abdomen is the most commonly used donor site in autologous breast reconstruction with the deep inferior epigastric artery perforator (DIEP) being most common. It has also been proven that there is a higher risk of complications in obese patients undergoing breast reconstruction, including delayed wound healing, seroma formation, flap failure, and need for reoperation (7).

Flap selection is another imperative aspect of preoperative consideration. There are multiple autologous options that can provide a suitable breast reconstruction for patients. These range from abdominally based DIEP flaps, muscle-sparing transverse rectus abdominis muscle flap (ms-TRAM), TRAM flaps, or superficial inferior epigastric artery perforator (SIAE) flaps. Thigh flaps can be based on either the gracilis muscle as the transverse upper gracilis muscle flap (TUG), profunda artery perforator (PAP) flap, or lateral thigh perforator flap (LTP). Gluteal flaps based on either the superior gluteal artery perforator (SGAP) or the inferior gluteal artery perforator (IGAP) can be performed. Posterior thorax flaps include the myocutaneous latissimus dorsi, thoracodorsal artery perforator flap (TDAP), and lumbar artery perforator flap. These different options all have benefits and risks, different degrees of difficulty, and different indications. Of note, abdominal flaps may be contraindicated in patients with prior abdominal incisions near vascular pedicles, so pre-operative imaging may be warranted. It is common for patients to undergo pre-operative computed tomography (CT) or magnetic resonance imaging (MRI) to identify perforator vessels, especially in perforator based free flaps (8).

The informed consent process for autologous breast reconstruction is a unique process, and should involve a thorough discussion of risks, benefits, and alternatives. Patients should be counseled on specific benefits of a durable, aesthetic, and low maintenance reconstruction, against specific risks of flap loss, bleeding or hematoma, infection, donor site wound, or recipient side wound. As with any surgical procedure, there is are risks associated with anesthetic that should be discussed as well. Alternatives that should be discussed include implant-based breast reconstruction and no reconstruction at all.

Patient education

There is inherent benefit to patient education in the process of autologous breast reconstruction. Well-informed patients do better post-operatively and have better outcomes (9). Patient education resources in breast reconstruction have proven to be beneficial. Specifically, education resources providing context on post-operative care and expected body image. Other aspects of breast reconstruction in which patient education is important is duration of the full process of breast reconstruction, specifics of surgical techniques, and post-operative instructions and restrictions. Another important point is that many patients want to meet with

their reconstructive surgeon more than once. The pre-operative investment in patient education results in patients who feel more empowered in their decision making, have realistic expectations of the process and results, and more satisfied patients (9,10).

Pre-habilitation

Pre-habilitation, or rehabilitation that occurs before surgery to help optimize patient physical strength, can be another beneficial intervention in autologous breast reconstruction. "Pre-hab" regimens can include general conditioning exercises, targeted exercise, nutritional interventions, psychological well-being, and smoking cessation (11). Studies have shown that in breast reconstruction patients pre-habilitation was beneficial in shoulder range of motion and upper extremity functional recovery. Other studies have shown that pre-operative exercises can reduce post-operative pain and also increase chances of feeling recovered sooner after surgery (12).

Antimicrobial prophylaxis

An infection, be it of the donor or recipient site, can have devastating complications for patients. In mastectomy cases the complication rate can be as high as 15% with the most common infections being due to skin microbes. Antimicrobial washes, most commonly with Hibiclens (Mölynlycke Health Care, Peachtree Corners, Georgia) are chlorhexidine washes typically by patients before surgery at set intervals. These skin decolonization protocols have been proven in multiple studies to decrease surgical site infection rates, especially those related to Staphylococcal infection (13). In addition, prophylactic antibiotics have been proven to reduce the rate of surgical site infections. Although there was common practice to continue antibiotics through the time drains were removed, there has not been proven to be benefit from prolonged antibiotic use beyond 24 hours duration (14-16). It should be noted that surgical site infections are proven to be more common in patients more advanced in age, patients who use tobacco, and also patients who underwent radiation therapy (16).

Venous thromboembolism prophylaxis

Reconstructive surgery poses a significant venous thromboembolism risk. In fact, this risk is almost twice that of a mastectomy or lumpectomy alone with large scale studies reporting rates of roughly 1/1,000 (17). Much of the research on venous thromboembolism risk in autologous breast reconstruction has focused on identifying risk factors for venous thromboembolism. Advanced age, history of venous thromboembolism, and current or prior malignancy have all been identified as risk factors for venous thromboembolism. In addition, immediate breast reconstruction patients are at higher risk for venous thromboembolism compared to delayed breast reconstruction patients (17). Using modified Caprini Score Index, low molecular weight heparin agents have been shown to be effective venous thromboembolism prophylaxis, typically used in concert with sequential compression devices and early ambulation (18). It should be noted that there is data supporting an increased rate of hemorrhagic complications in breast surgery patients when utilizing low molecular weight heparin as compared to unfractionated heparin (19).

Anesthetic and analgesic interventions

Regardless of donor site, multimodal pain control is critical to optimizing patient recovery and experience. Typical regimens include combinations of scheduled acetaminophen, non-steroidal anti-inflammatory (NSAIDs) medications, and gabapentin. Non-selective NSAIDs may be associated with increased hematoma risk and thus some programs prefer COX-II inhibitors as alternatives. A specific NSAID, ketorolac, has been found to be especially efficacious for postoperative pain control and a recent review demonstrated no difference in hematoma rates between patients who did and did not receive ketorolac (20). Opioids are typically used on an as needed basis (1,21-23).

Regional anesthesia involves the injection of local anesthetic in proximity to regional nerves to provide pain relief for hours to days. With more pain relief being provided by regional anesthesia and from non-opioid agents, they can reduce opioid pain medication use post-operatively (24). One study by Gatherwright *et al.* showed statistically significant decreases in narcotics in total use and per day use. In addition, patients were also able to get out of bed earlier (25). There are a variety of types of blocks that can be used in autologous breast reconstruction. The most common types include transversus abdominis plan (TAP) blocks, paravertebral blocks, erector spinae plane (ESP) blocks, and chest wall blocks of which there are two versions, PECS I and PECS II. Studies have shown that the addition of regional anesthesia, specifically of the chest

wall will decrease post-operative opioid requirements and decrease length of stay post-operatively (26). Specific to TAP blocks, a meta-analysis by Chi *et al.* showed that TAP blocks can decrease hospital stay by roughly 1.0 days and decrease opioid use without increasing complication rates or negatively affecting cost (27). ESP blocks have also been shown to decrease post-operative opioid consumption, while being similar in efficacy to paravertebral blocks (28,29). In a study specifically comparing PECS II blocks versus ESP blocks in breast surgery patients the PECS II block performed better, showing less opioid use, lower pain scores, and higher lengths of time to request opioids (30).

A specific note should be made about the use of liposomal bupivacaine in regional anesthesia for autologous breast reconstruction patients. Liposomal bupivacaine has the benefit of being able to extend pain relief provided by regional anesthesia due to its increased half-life compared to other commonly used local anesthetic agents (8). In implant-based breast reconstruction undergoing regional anesthesia with liposomal bupivacaine research has shown decreases in opioid use, length of stay, and improved cost savings for patients (31). A study by Haddock *et al.* showed that liposomal bupivacaine TAP blocks were an effective adjunct in addition to an ERAS protocol. In their study, while ERAS protocols decreased opioid and length of stay in autologous breast reconstruction patients, these benefits were made even more significant with the addition of liposomal bupivacaine TAP blocks (32). Additional evidence in favor of liposomal bupivacaine in breast reconstruction is assessing its effect on urinary retention. Clary *et al.* showed that liposomal bupivacaine, in addition to decreasing opioid consumption, allowed for earlier foley catheter removal in autologous breast reconstruction patients (33). There are several other reviews supporting the notion that liposomal bupivacaine is a safe intervention that can reduce narcotic use and improve pain control overall (34). However, a prospective randomized control trial by Ha *et al.* compared liposomal bupivacaine against bupivacaine hydrochloride in TAP blocks for abdominally based free flap breast reconstruction patients on ERAS pathways and found no significant difference between the groups in opioid consumption, pain scores, or length of stay (24).

Operative efficiency

Effective operating room time management can limit complications associated with prolonged operating room time (35). There are several methods of decreasing operating time both preoperatively and intraoperatively that have proven to be effective. First, pre-operative imaging guided perforator identification. Pre-operative imaging has been proven to simultaneously decrease operating room time and provide cost savings to patients (36). Options for pre-operative imaging include ultrasound, computed tomography (CTA), magnetic resonance angiography (MRA), Doppler sonography, and colour Doppler ultrasonography. As the most commonly used method, CTA presents an excellent and reproducible results allowing for three-dimensional assessment of perforator anatomy. One should be sure to consider the potential ionizing radiation effects, potential contrast dilemmas in renal disease patients, and contrast sensitivity. MRA has been shown to be as effective at demonstrating perforator anatomy, without the potential ionizing radiation issues (35). CTA's wide accessibility and positive predictive value of up to 100% make it the most commonly used modality (37). Pre-operative imaging has been proven to be of value in autologous breast reconstruction not only in DIEP flap patients, but also patients undergoing PAP flaps and SIEA flap reconstruction (32,38).

Another intervention that can have a major impact on operative efficiency is the utilization of a co-surgeon. This allows for dedicated teamwork in the operating room, and progression of multiple surgical sites simultaneously. A study by Weichman *et al.* showed significant decreases in operating time, length of stay, and post-operative complications with the utilization of a co-surgeon in both bilateral and unilateral autologous breast reconstruction (39). Mericli *et al.* have also shown decreased complications and also reduced costs with the use of a co-surgeon in autologous breast reconstruction (40). One specific post-operative complication that has been shown to be related to increased operating room time is deep vein thrombosis (17). Delayed breast reconstruction, which theoretically results in shorter operating room times, would help prevent complications associated with prolonged operating room times such as DVT and wound healing issues. It should be noted that obesity has also proven to be a risk factor for wound healing issues and deep vein thrombosis (17,41). Considering this, the utilization of a co-surgeon and the overall prioritization of operative efficiency is vitally important to the optimization of perioperative outcomes in patients at higher risk for complications associated with increased operating room times (17,39).

Flap checks

Monitoring of free flaps after surgery is an essential component of reconstructive microsurgery. It begins in the operating room, continues in the post-anesthesia care unit, and then progresses to the hospital floor. There are many different ways institutions execute this facet of patient care. The goal of effective free flap monitoring is to detect flap compromise early, allowing for early intervention and salvage. There are different methods of flap monitoring with variable invasiveness, however there is no gold standard method of flap monitoring. Clinical exam, hand-held Doppler probe, implantable Doppler, Laser Doppler, tissue oxygen tension measurement, tissue pH levels, surface temperature, fluorescein dye mapping, microdialysis, near-infrared spectroscopy, and nuclear medicine studies are all options available. The most commonly used methods are clinical exam and hand-held Doppler exam (42). These methods have the benefit of being able to be performed by the surgeon, residents, and nursing staff. All devices and techniques will have a certain "false-negative" and "false-positive" rate. Studies on internal Doppler were initially plagued by high false positive rates which led to unnecessary re-explorations (43). They have benefits in buried flaps but do possess a higher false positive rate than hand-held Doppler (1). Laser Doppler equipment is expensive, limiting availability, however the ability to follow a flap perfusion trend allows a surgeon to observe changes in flap perfusion and anticipate decline. Near-infrared angiography is useful for visualizing zonal perfusion, but only shows a static assessment of flap perfusion. Photography can be used to compare flap trends and can also be sent to the surgeon from bedside to allow for their assessment remotely. In breast reconstruction, data supports utilization of hand-held Doppler and clinical assessment for frequent monitoring in the initial 72 hours post-operatively. Intervals may vary between institutions, but hourly monitoring for the first 24 hours, then every two-hour monitoring for the next 24 hours, then intervals of 4 hours for the next 24 hours are supported by the ERAS Society. A note should be made that a well-trained and experienced nursing staff is an indispensable tool in patient monitoring in reconstructive microsurgery (1,42,43).

Activity restrictions

While post-operative restrictions may help promote healing and pain control, there also known benefits to early mobilization after surgery. Studies have shown that early mobilization within 24 hours after surgery can help decrease pain levels and decrease total length of stay (1). There also psychological benefits to early mobilization after surgery. Post-discharge physical therapy has been shown to improve mobility and increase quality of life (44).

Blood transfusion

The delivery of blood products can be a controversial issue in the post-operative setting after free flap breast reconstruction. Literature from Appleton *et al.* has shown the patients undergoing bilateral free flap reconstruction and with overall longer operating room times are more likely to require blood transfusion in the post-operative setting. In the study, the authors note that patients either defined as obese or undergoing bilateral free flap reconstruction were more likely to require blood product administration. The authors also found that post-operative complications, defined as flap loss, fat necrosis, seroma, hematoma, infection, venous congestion, arterial thrombosis, abdominal complication, and postoperative anemia were all more likely to occur in the transfusion population than the non-transfusion population at almost twice the rate (45).

Length of stay and discharge

Evaluation of when a patient no longer requires inpatient hospital care is a multi-faceted decision-making process. It is essential in a patient's post-operative course that they feel safe and comfortable mobilizing, have re-gained gastrointestinal function, are tolerating a diet, their pain is controlled with oral medications only, and also that they feel comfortable performing activities of daily living that they will have to do themselves at home. These are broad guidelines used by many institutions (21,22). Specific potential complications can result in delaying discharge are flap necrosis, ileus, and urinary retention. Clear discharge instructions set expectations with patients and allow for less visits to the emergency department or calls with questions to the clinic. The definite number of days a patient should remain hospitalized can be variable. Examination from the perspective of cost-effectiveness has shown that a three-day hospitalization may be optimal. Mericli *et al.* also showed in this study that when examining the optimal length of stay from a quality-of-life perspective a three-day hospitalization was most advantageous (46). A three-day length of stay

is also supported by the fact that research has shown that there is minimal cost effectiveness in attempting to salvage a flap after this amount of time. There was also shown to be minimal value in flap monitoring after 48 hours, due to flap thrombosis being most common within the first 48 hours and poor flap salvage rates after this amount of time (47). Predictors of increased length of stay include increased OR time, need for reoperation, transfusion, surgical site infection, obesity, diabetes mellitus, and immediate reconstruction (48). Patients typically follow-up within two to four weeks after autologous breast reconstruction, however, this may vary institution to institution.

Conclusions

The success of an operation is not only dictated by what occurs in the operating room. Critical portions of patient care happen both before and after surgery. The principles of standardization and ERAS have allowed for improved outcomes and more streamlined care in this patient population at many institutions.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Ketan M. Patel and Ara A. Salibian) for the series "Advances in Microsurgical Breast Reconstruction" published in *Gland Surgery*. The article has undergone external peer review.

Peer Review File: Available at https://gs.amegroups.com/article/view/10.21037/gs-22-608/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-22-608/coif). The series "Advances in Microsurgical Breast Reconstruction" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Temple-Oberle C, Shea-Budgell MA, Tan M, et al. Consensus Review of Optimal Perioperative Care in Breast Reconstruction: Enhanced Recovery after Surgery (ERAS) Society Recommendations. Plast Reconstr Surg 2017;139:1056e-71e.
2. Sebai ME, Siotos C, Payne RM, et al. Enhanced Recovery after Surgery Pathway for Microsurgical Breast Reconstruction: A Systematic Review and Meta-Analysis. Plast Reconstr Surg 2019;143:655-66.
3. Ochoa O, Rajan M, Garza R 3rd, et al. Enhanced Recovery Pathway Reduces Hospital Stay and Opioid Use in Microsurgical Breast Reconstruction: A Single-Center, Private Practice Experience. Plast Reconstr Surg 2022;150:13e-21e.
4. 'Enhanced+Recovery+after+Surgery+Plastic+Surgery' - Search Results - Pubmed." National Center for Biotechnology Information, U.S. National Library of Medicine. Available online: https://pubmed.ncbi.nlm.nih.gov/?term=%22enhanced%2Brecovery%2Bafter%2Bsurgery%2Bplastic%2Bsurgery%22&sort=date&size=200
5. Tan YY, Liaw F, Warner R, et al. Enhanced Recovery Pathways for Flap-Based Reconstruction: Systematic Review and Meta-Analysis. Aesthetic Plast Surg 2021;45:2096-115.
6. "Guidelines Breast." ERAS® Society, 1 Oct. 2021. Available online: https://erassociety.org/guidelines/#filter=.breast
7. Bigarella LG, Ballardin AC, Couto LS, et al. The Impact of Obesity on Plastic Surgery Outcomes: A Systematic Review and Meta-analysis. Aesthet Surg J 2022;42:795-807.
8. Nahabedian MY. Breast Reconstruction. In: Flaps and Reconstructive Surgery. Wei FC, Mardini S, editors. 2nd edition. Edinburgh: Elsevier, 2017.

9. Pestana IA. Patient-Guided Breast Reconstruction Education. Cureus 2020;12:e9070.
10. Ho AL, Klassen AF, Cano S, et al. Optimizing patient-centered care in breast reconstruction: the importance of preoperative information and patient-physician communication. Plast Reconstr Surg 2013;132:212e-20e.
11. Fiser C, Crystal JS, Tevis SE, et al. Treatment and Survivorship Interventions to Prevent Poor Body Image Outcomes in Breast Cancer Survivors. Breast Cancer (Dove Med Press) 2021;13:701-9.
12. Yang A, Sokolof J, Gulati A. The effect of preoperative exercise on upper extremity recovery following breast cancer surgery: a systematic review. Int J Rehabil Res 2018;41:189-96.
13. Baker NF, Brown O, Hart AM, et al. Preventing Infection in Implant-based Breast Reconstruction: Evaluating the Evidence for Common Practices and Standardized Protocols. Plast Reconstr Surg Glob Open 2022;10:e4208.
14. Gort N, van Gaal BGI, Tielemans HJP, et al. Positive effects of the enhanced recovery after surgery (ERAS) protocol in DIEP flap breast reconstruction. Breast 2021;60:53-7.
15. Thomas R, Alvino P, Cortino GR, et al. Long-acting versus short-acting cephalosporins for preoperative prophylaxis in breast surgery: A randomized double-blind trial involving 1,766 patients. Chemotherapy 1999;45:217-23.
16. Liu DZ, Dubbins JA, Louie O, et al. Duration of antibiotics after microsurgical breast reconstruction does not change surgical infection rate. Plast Reconstr Surg 2012;129:362-7.
17. Masoomi H, Paydar KZ, Wirth GA, et al. Predictive risk factors of venous thromboembolism in autologous breast reconstruction surgery. Ann Plast Surg 2014;72:30-3.
18. Lemaine V, McCarthy C, Kaplan K, et al. Venous thromboembolism following microsurgical breast reconstruction: an objective analysis in 225 consecutive patients using low-molecular-weight heparin prophylaxis. Plast Reconstr Surg 2011;127:1399-406.
19. Hardy RG, Williams L, Dixon JM. Use of enoxaparin results in more haemorrhagic complications after breast surgery than unfractionated heparin. Br J Surg 2008;95:834-6.
20. Nguyen BN, Barta RJ, Stewart CE, et al. Toradol following Breast Surgery: Is There an Increased Risk of Hematoma? Plast Reconstr Surg 2018;141:814e-7e.
21. Bonde CT, Khorasani H, Elberg J, et al. Perioperative Optimization of Autologous Breast Reconstruction. Plast Reconstr Surg 2016;137:411-4.
22. Bonde C, Khorasani H, Eriksen K, et al. Introducing the fast track surgery principles can reduce length of stay after autologous breast reconstruction using free flaps: A case control study. J Plast Surg Hand Surg 2015;49:367-71.
23. Bonde C, Khorasani H, Hoejvig J, et al. Cyclooxygenase-2 inhibitors and free flap complications after autologous breast reconstruction: A retrospective cohort study. J Plast Reconstr Aesthet Surg 2017;70:1543-6.
24. Ha AY, Keane G, Parikh R, et al. The Analgesic Effects of Liposomal Bupivacaine versus Bupivacaine Hydrochloride Administered as a Transversus Abdominis Plane Block after Abdominally Based Autologous Microvascular Breast Reconstruction: A Prospective, Single-Blind, Randomized, Controlled Trial. Plast Reconstr Surg 2019;144:35-44.
25. Gatherwright J, Knackstedt RW, Ghaznavi AM, et al. Prospective, Randomized, Controlled Comparison of Bupivacaine versus Liposomal Bupivacaine for Pain Management after Unilateral Delayed Deep Inferior Epigastric Perforator Free Flap Reconstruction. Plast Reconstr Surg 2018;141:1327-30.
26. Atwez A, Martinez C, Mujadzic T, et al. The Role of Maximal Locoregional Block in Autologous Breast Reconstruction. Ann Plast Surg 2022;88:612-6.
27. Chi D, Chen AD, Ha AY, et al. Comparative Effectiveness of Transversus Abdominis Plane Blocks in Abdominally Based Autologous Breast Reconstruction: A Systematic Review and Meta-analysis. Ann Plast Surg 2020;85:e76-83.
28. Park S, Park J, Choi JW, et al. The efficacy of ultrasound-guided erector spinae plane block after mastectomy and immediate breast reconstruction with a tissue expander: a randomized clinical trial. Korean J Pain 2021;34:106-13.
29. Xiong C, Han C, Zhao D, et al. Postoperative analgesic effects of paravertebral block versus erector spinae plane block for thoracic and breast surgery: A meta-analysis. PLoS One 2021;16:e0256611.
30. Bakeer A, Abdallah NM. Erector Spinae Plane Block Versus PECS Block Type II for Breast Surgery: A Randomized Controlled Trial. Anesth Pain Med 2022;12:e122917.
31. Motakef S, Wong WW, Ingargiola MJ, et al. Liposomal Bupivacaine in Implant-Based Breast Reconstruction. Plast Reconstr Surg Glob Open 2017;5:e1559.
32. Haddock NT, Garza R, Boyle CE, et al. Defining Enhanced Recovery Pathway with or without Liposomal Bupivacaine in DIEP Flap Breast Reconstruction. Plast Reconstr Surg 2021;148:948-57.
33. Clary Z, Nazir N, Butterworth J. Transversus Abdominis

Plane Block With Liposomal Bupivacaine Versus Thoracic Epidural for Postoperative Analgesia After Deep Inferior Epigastric Artery Perforator Flap-Based Breast Reconstruction. Ann Plast Surg 2020;85:e24-6.
34. Vyas KS, Rajendran S, Morrison SD, et al. Systematic Review of Liposomal Bupivacaine (Exparel) for Postoperative Analgesia. Plast Reconstr Surg 2016;138:748e-56e.
35. Cina A, Barone-Adesi L, Rinaldi P, et al. Planning deep inferior epigastric perforator flaps for breast reconstruction: a comparison between multidetector computed tomography and magnetic resonance angiography. Eur Radiol 2013;23:2333-43.
36. Uppal RS, Casaer B, Van Landuyt K, et al. The efficacy of preoperative mapping of perforators in reducing operative times and complications in perforator flap breast reconstruction. J Plast Reconstr Aesthet Surg 2009;62:859-64.
37. Masia J, Clavero JA, Larrañaga J, et al. Preoperative planning of the abdominal perforator flap with multidetector row computed tomography: 3 years of experience. Plast Reconstr Surg 2008;122:80e-1e.
38. Piorkowski JR, DeRosier LC, Nickerson P, et al. Preoperative computed tomography angiogram to predict patients with favorable anatomy for superficial inferior epigastric artery flap breast reconstruction. Ann Plast Surg 2011;66:534-6.
39. Weichman KE, Lam G, Wilson SC, et al. The Impact of Two Operating Surgeons on Microsurgical Breast Reconstruction. Plast Reconstr Surg 2017;139:277-84.
40. Mericli AF, Chu CK, Sisk GC, et al. Microvascular Breast Reconstruction in the Era of Value-Based Care: Use of a Cosurgeon Is Associated with Reduced Costs, Improved Outcomes, and Added Value. Plast Reconstr Surg 2022;149:338-48.
41. Nelson JA, Fischer JP, Radecki MA, et al. Delayed autologous breast reconstruction: factors which influence patient decision making. J Plast Reconstr Aesthet Surg 2013;66:1513-20.
42. Neligan P. Principles and Techniques of Microvascular Surgery. In: Plastic Surgery. London: Elsevier, 2018:444-72.
43. Rimler J, Nguyen A, Evans GRD. Postoperative Care. In: Wei FC, Mardini S. Flaps and reconstructive surgery editors. 2nd edition. Edinburgh: Elsevier, 2017:348-56.
44. Persing S, Manahan M, Rosson G. Enhanced Recovery After Surgery Pathways in Breast Reconstruction. Clin Plast Surg 2020;47:221-43.
45. Appleton SE, Ngan A, Kent B, et al. Risk factors influencing transfusion rates in DIEP flap breast reconstruction. Plast Reconstr Surg 2011;127:1773-82.
46. Mericli AF, Selber JC, Largo RD, et al. The Optimal Length of Stay after Microvascular Breast Reconstruction: A Cost-Utility Analysis. Plast Reconstr Surg 2022;150:279e-89e.
47. Jablonka EM, Lamelas AM, Kanchwala SK, et al. A Simplified Cost-Utility Analysis of Inpatient Flap Monitoring after Microsurgical Breast Reconstruction and Implications for Hospital Length of Stay. Plast Reconstr Surg 2019;144:540e-9e.
48. Kotha VS, Abadeer AI, Amdur RL, et al. A Critical Examination of Length of Stay in Autologous Breast Reconstruction: A National Surgical Quality Improvement Program Analysis. Plast Reconstr Surg 2021;147:24-33.

Cite this article as: DeVito RG, Craft L, Campbell CA, Stranix JT. Optimizing perioperative outcomes in autologous breast reconstruction. Gland Surg 2023;12(4):508-515. doi: 10.21037/gs-22-608