

Final 24-hour Drain Output and Postoperative Day Are Poor Indicators for Appropriate Drain Removal

Charleston Chua, MD*
 Corey M. Bascone, MD*
 Clifford Pereira, MD*
 Josephine Hai, BS†
 Jeannie Park, BS†
 Kelsey Hideshima, BS†
 Satninderdeep Bhatti, BS†
 Shadi Nemanpour, BS†
 Bella Leon, BS†
 Gloria Han, BS†

Background: Drains are used in plastic surgery to remove excess fluid while ameliorating complications. However, there is a paucity of evidence supporting guiding parameters on when to discontinue a drain. The aim of our study was to determine whether two of the most common parameters, drain volume 24 hours before removal or postoperative day, are valid indicators for drain removal.

Methods: A retrospective chart review was conducted for surgical operations performed by our division between July 2014 and May 2019. Of the 1308 patients, 616 had a drain and a complete record. Demographics, medical history, operative time, antibiotic use, anatomic site, donor/recipient, and complication type were recorded. Complications were defined as events that deviated from expected postoperative course or required pharmacological/procedural intervention. *T*-test and Chi square were used to analyze data.

Results: In total, 544 patients were in the no complication group, and 72 were in the complication group. The complication group patients had drains removed later than patients in the no complication group (15.7 days versus 12.5 days, $P = 0.0003$) and had similar final 24-hour drain volumes versus patients in the no complication group (16.7 mL versus 18.8 mL, $P = 0.2548$). The complication group had more operations on the pelvis (11% versus 2.1%; $P = 0.000017$) or thigh (8.5% versus 3.4%; $P = 0.029$).

Conclusions: Our data suggest neither postoperative day nor 24-hour volume before drain removal are valid indicators for removal. Late removal correlates with more complications; however, persisting output leading to later removal may be predictive of an impending complication rather than delays in drain removal causing the complication. (*Plast Reconstr Surg Glob Open* 2022;10:e4160; doi: 10.1097/GOX.0000000000004160; Published online 14 April 2022.)

INTRODUCTION

Over 5.9 million reconstructive and 18.1 million cosmetic procedures are performed in the United States each year.¹ Closed suction drains are commonly used in most of these cases; however, much controversy exist in the literature regarding their use and timing of removal.² In a survey of 4669 American Society of Plastic Surgeons and Canadian Society of Plastic Surgeons, more than 81%

reported closed suction drain use in breast reconstruction. Over 93% used volume criteria for drain removal with over 86% removing drains once drain output was less than 30 mL per 24 hour.³ Furthermore, over 90% of those surveyed used drains at the donor site in autologous flap reconstructions, with 86.4% recommending removal with drainage less than 30 mL per 24h. Drain output in the preceding 24 hours of less than 30 ml has been both questioned and supported in discussions regarding removal criteria.⁴⁻⁶ The goal of our study was to validate whether the postoperative day or preceding 24-hour drain volume are good indicators for drain removal in plastic surgery procedures.

METHODS

An institutional review board-approved retrospective chart review was conducted for all surgical operations performed by the plastic surgery division at UC Davis Medical Center between July 2014 and May 2019 with dates chosen as it was the launch of our electronic medical record.

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From the *Division of Plastic and Reconstructive Surgery, University of California Davis, Sacramento, Calif.; and †University of California Davis School of Medicine, Sacramento, Calif.

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Patients were first screened for procedures where a drain was reasonably expected to be placed. These procedures included pedicled or free tissue transfer for traumatic or tumor extirpation wounds, reconstruction for pressure ulcers, abdominoplasties, circumferential body lift, thigh-plastics, brachioplasties, breast augmentations, autologous and alloplastic breast reconstructions, reduction mammoplasties, mastopexies, and breast prosthesis explantations. Of the total of 1308 patients undergoing the above procedures, 710 had drains placed. Of these 710 patients, 616 had at least 90-day follow up with accurate records of the postoperative day of drain removal and drain output in the final 24 hours before drain removal.

Data for this study were retrieved from patient records and included demographics (ie, age and BMI), comorbidities (ie, smoking status, ASA score, diabetes, and bleeding dyscrasias), operative time, antibiotic use, surgical site, donor site (if applicable), and postoperative complications following reconstruction (ie, seroma, hematoma, cellulitis, abscess, or wound dehiscence). Patients were divided into a complication group (CG) and a no complication group (NCG), which were stratified by the presence of Clavien-Dindo Grade 2 or higher, as it was felt Grade 1 complications were not significantly impacted by any drain parameters. Another subset was created differentiating planned or unplanned drain removal as an internal control whether a defined postoperative day or final 24-hour drain output made an impact on complication rates.

Statistical differences between demographic groups were assessed using the Fisher exact test for categorical variables and the Mann-Whitney U test for continuous variables, setting the significance level at below 5%. Fisher exact test was used to analyze categorical variables with fewer than five subjects, and Chi square test was used to analyze categorical variable with more than five subjects. All statistical analyses were performed using Excel.

RESULTS

There were 616 patients who underwent reconstructive surgery by one of six attending plastic surgeons at our institute who were followed up for a minimum of 90 days with accurate documentation of drain removal day and preceding 24-hour drain output. The average age of patients enrolled was 51.75 ± 0.51 years (Mean \pm SEM), and average BMI of patients was 27.6 ± 0.2 .

There were 544 patients in the NCG (average age 51.8 ± 0.6 and average BMI 27.4 ± 0.2) and 72 in the CG (average age 51.1 ± 1.3 and average BMI 28.4 ± 0.6) and both groups having matched for both age and BMI ($P = 0.68$ and $P = 0.13$, respectively). Patients in the CG were further divided into type of complication. In the CG, seromas (15, 20.8%), hematoma (1, 1.4%), abscess (11, 15.3%), and wound separation requiring dressing changes (37, 51.4%) were included, with several patients having more than one complication simultaneously (See Table 1). Patients in the CG typically had a recorded volume of 16.7 ± 1.6 mL as reported by the patient or caregiver in the 24 hours preceding removal and patients in

Takeaways

Question: What is a better indicator for drain removal, postoperative day or drain output?

Findings: There were no differences in complication rates, based on the volume of recorded drain output in the last 24 hours before removal, nor a difference in complications, including seroma, between patients who had donor site drain removal early (by day 3), compared with those who had drain removal late (after day 3).

Meaning: Our data support early drain removal except for those involving the groin, pelvis, or thigh. Drain placement may be avoided if tissue apposition is optimized via surgical technique.

the NCG typically had a recorded volume of 18.8 ± 0.5 mL as reported by the patient or caregiver in the 24 hours preceding removal ($P = 0.25$). The CG patients had their drain removed at 15.7 ± 1.1 days postoperative, whereas the NCG patients usually had their drain removed at 12.5 ± 0.3 days postoperative ($P = 0.0003$).

Patient comorbidities such as bleeding diathesis (5.6% versus 3.3%; $P = 0.29$), diabetes mellitus (15.3% versus 12.7%; $P = 0.44$), cardiac disease (16.7% versus 13.3%; $P = 0.35$), pulmonary disease (5.6% versus 6.6%; $P = 0.87$), hepatic disease (4.2% versus 3.1%; $P = 0.56$), or renal disease (9.7% versus 8.4%; $P = 0.59$), did not affect complication rates/ profiles of either group. Surprisingly, tobacco abuse was also insignificant in influencing complication rates, with 55.6% of the CG and 66% of the NCG being nonsmokers ($P = 0.47$), 36.1% of the CG and 28.1% of the NCG ($P = 0.38$) being former smokers (defined as no tobacco use longer than 3 months), and current smokers comprising only 8.3% of the CG and 5.9% of the NCG ($P = 0.38$). Perioperative factors such as operative time (241 minutes versus 214 minutes; $P = 0.14$), antibiotic use (51.4% versus 56.3%; $P = 0.98$) or length of drain insertion (13.8 days versus 11.9 days; $P = 0.33$), and weight of specimen removed (1107g versus 1037g; $P = 0.67$) showed no difference in complication rates between the two groups.

Anatomic site of surgery was another potential difference thought to affect the complication rate. The pelvis (11% versus 2.1%; $P = 0.000017$) and thigh (8.5% versus 5.7%; $P = 0.029$) were the only areas that seem to have higher incidence of complication compared with all other areas of the body. Operations involving the head (1.2% versus 1.6%; $P = 0.78$), chest (1.2% versus 2.2%; $P = 0.56$), breast (40.2% versus 57.9%; $P = 0.087$), back (7.3% versus 5.8%; $P = 0.62$), abdomen (22% versus 19.6%; $P = 0.69$), buttock (1.2% versus 1.5%; $P = 0.83$), and leg (7.3% versus

Table 1. Complication Profile amongst All 72 Patients in the Complication Group

| Complication Profile of CG (CG Total = 72 Patients) | Rate (%) |
|---|----------|
| Hematoma | 1.6% |
| Abscess | 17.2% |
| Seroma | 23.4% |
| Wound separation | 57.8% |

5.7%; $P = 0.58$) made no difference on the complication rate (see Fig. 1). Furthermore, an area being a donor (10% versus 10.8%; $P = 0.85$) or recipient (16.3% versus 10.3%; $P = 0.15$) also made no difference on the complication rate.

DISCUSSION

Closed suction drains have been classically used in many aspects of reconstructive surgery. However, there is still a lack of conclusive evidence in the literature, as well as consensus among surgeons regarding the necessity of use and timing of removal. The goal of our study was to validate whether the postoperative day or preceding 24-hour drain volume are good indicators for drain removal in plastic surgery procedures. Comparative outcomes among a variety of plastic and reconstructive surgical procedures were analyzed, and it was found that the incidence of seroma, hematoma, and wound dehiscence did not occur as a direct cause of high drain output, nor occur any less frequently in patients who had a drain in-situ for a longer duration. According to both the American and Canadian Society of Plastic Surgeons, the overwhelming majority of plastic surgeons support a drain output of 30 mL over the preceding 24 hours as the main

criteria for drain removal.³ Despite this widely held belief, our results indicate that complications can occur despite the drain output being as low as 16.7–18.8 ml over the preceding 24 hours at the time of drain removal (see Fig. 2). We postulate this similarity has less to do with how much longer the drain needs to stay in, but rather, how little the tissue apposition has occurred in the area of tissue dissection. Dissimilar to prior theories about suction from negative pressure drains aiding in tissue apposition, our study indicates that the presence of a drain may actually have no positive effect on apposition, and may even inhibit it, due to foreign body presence, preventing tissue plane approximation at the wound base.⁷

To tease out the significant factors that may affect tissue apposition, we compared patient factors (ie, age, gender, comorbidities), surgical versus donor sites, pre- and postoperative factors. Operative time, the weight of tissue resected, and even perioperative antibiotic use also did not affect complication rates. Interestingly, surgical site significantly affected complication rates with the pelvic/groin and thigh regions have a higher incidence of complications than any other area in the body (see Table 1). The cause of this finding may be multifactorial, but we think the increased rate of seroma formation was most

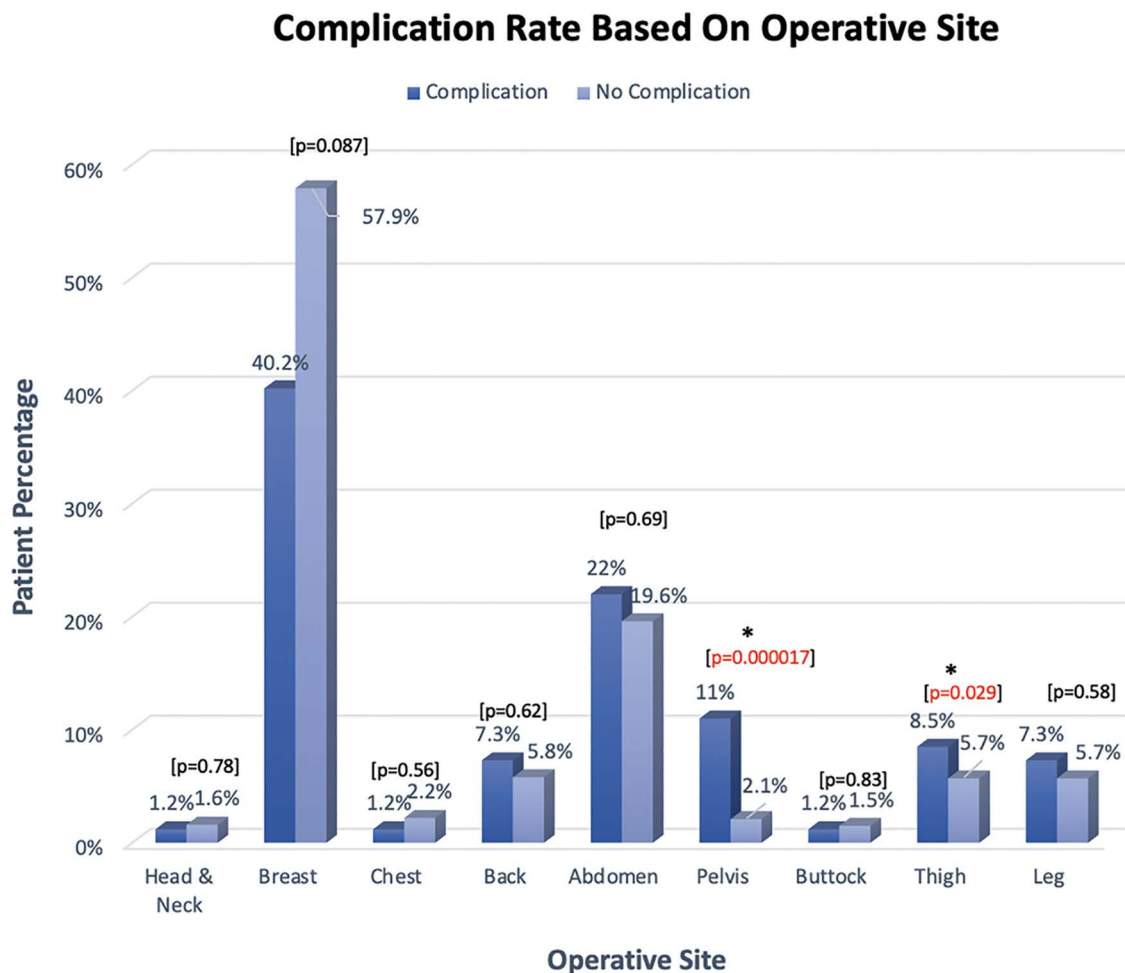


Fig. 1. Complication rates based on all operative sites in 616 patients.

Influence of Drain Output on Complication Frequency

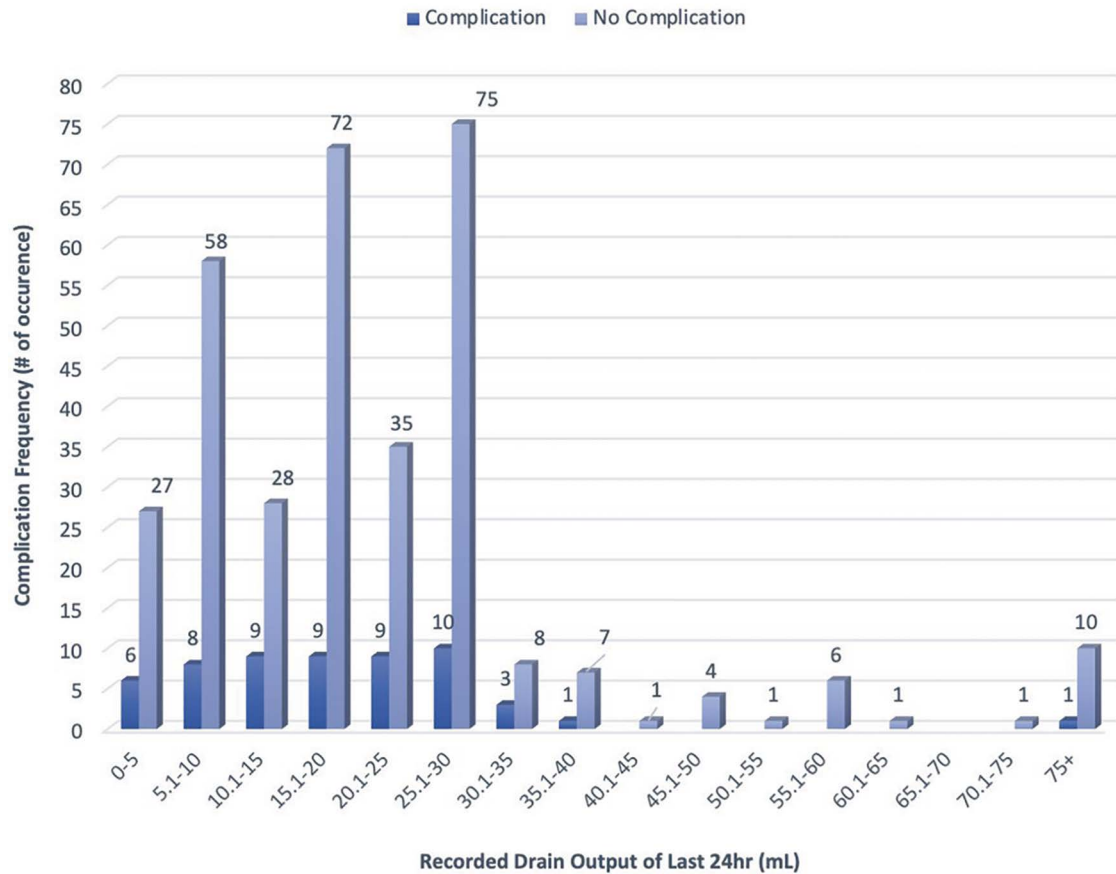


Fig. 2. Frequency of complication based on recorded drain output.

likely due to the higher concentration of lymphatics and therefore higher risk of disruption of lymphatic channels in this area.⁸⁻¹⁰ Additionally, the groin area is a difficult area to keep dry and/or immobilized, causing maceration and decreased tissue apposition, respectively. Both these factors can increase infection and seroma rates, respectively.

The inflammatory stage of healing is responsible for the fluid engorgement and initial drainage seen in a freshly closed surgical incision.¹¹ An increase in drainage at this time can be a sign of extensive tissue damage or can result from increasing wound depth.¹² Surgical technique and tissue respect is paramount in minimizing tissue damage during surgery. For example, the use of electrocautery versus a scalpel during surgical dissection has been shown to incite an increased inflammatory response, which in turn increases capillary permeability and fluid extravasation within the wound.¹³ The use of electrocautery on adipose tissue in an area such as the abdomen has been shown to increase the incidence of postoperative seroma.^{14,15}

It is quite possible that the drain itself is a foreign body that incites tissue reaction and prevents tissue apposition. One large retrospective study on prosthetic-based breast

reconstruction patients found that infection rate increased significantly with each additional week of drain retention.¹⁶ They summarized that drains could be removed as early as postoperative day 7, even when the drainage was over 30 mL in a 24-hour period. Our data similarly show that in patients who underwent breast reconstruction with latissimus dorsi flaps, there were no statistical differences in postoperative complications, (including seroma rates), between patients who had the donor site drain removed by day 3 regardless of output, compared with those whose drains were removed after day 3 with drain volumes less than 30 cm³ in the preceding 24 hours. Removal instructions were by volume, such that their drains were removed after day 3. Furthermore, we did not note any differences between the two groups even after adding the data of patients whose drains accidentally fell out within 3 days. Interestingly, we noted a shorter hospital inpatient stay with early drain removal (by day 3). The literature therefore supports our view that drains should be removed earlier for better tissue apposition. This could translate to reduced need for antibiotic coverage, and reduced hospital stays and costs.

Overall, choosing the optimal time to remove wound drains for the best clinical outcome remains

controversial. Current practices call for antibiotic coverage until drain removal, or a 5- to 7-day course even after drain removal, despite the lack of consensus or evidence supporting either practice.^{17–20} However, there is strong evidence that shows three to four times increase in surgical site infections in breast reconstruction patients who only received preoperative antibiotics, versus those who received pre- and postoperative antibiotics until all drains were removed. We therefore recommend pre- and postantibiotic coverage until drain removal, while practicing early drain removal by day 3, in the hope that this facilitates more surgeon control over operative outcomes.²¹

CONCLUSIONS

Closed suction drainage facilitates the removal of excess exudate and material, which can hamper the healing process, while also allowing for a certain amount of moisture to remain in tissues to promote regeneration and lessen inflammation.¹⁵ Additionally, studies have highlighted a benefit in placing wound drains status post mastectomy and immediate reconstruction, to aid in detecting postoperative bleeding, and decreasing fluid accumulation that may prevent skin flaps from adhering to the underlying tissue.¹⁶ However, a recent Cochrane Review has found limited evidence for drain use in both reconstruction and reduction mammoplasty. They also noted an increase in associated hospital stay when drains were used (average inpatient stay = 3 days).⁴ However, with acellular dermal matrices playing a crucial role in breast reconstruction, and literature reporting an increased risk of seroma with its use, it is likely that routine drain placement after breast reconstruction is here to stay.¹⁷ Our data demonstrate the need for surgeons to not only consider when and where to place drains, but also when to remove the drains. Attention to detail including tissue respect, appropriate dissection, and tissue apposition are all paramount in reducing postoperative complications.

The results our study suggest no differences in complication rates, based on the volume of recorded drain output in the last 24 hours before removal. Additionally, we saw no difference in complications, including seroma, between patients who had donor site drain removal early (by day 3), compared with those who had drain removal late (after day 3), following breast reconstruction with latissimus dorsi flap. Although we acknowledge that a randomized controlled multicentric study would be required to corroborate our findings, our data strongly suggest significant patient benefits with early drain removal, including shorter hospital inpatient stay and subsequent reduction in hospital costs, with no change in complication rates. We further recommend in this article, the recommended guideline of early drain removal for breast reconstruction, and any reconstructive surgery except for those involving the groin, pelvis, or thigh. Drain placement may be avoided in other regions of the body if tissue apposition is able to be optimized. These evidence-based guidelines fall within the important concept of fast-track surgery and enhanced recovery.^{22,23}

Charleston Chua, MD

Division of Plastic and Reconstructive Surgery
University of California Davis
2335 Stockton Blvd, 5th Floor
Sacramento, CA 95817
E-mail: chua.charleston@gmail.com

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REFERENCES

1. American Society of Plastic Surgeons. American Society of Plastic Surgeons report of the 2019 plastic surgery statistics. Published 2019. Available at <https://plasticsurgerycal.com/wp-content/uploads/2021/08/plastic-surgery-statistics-full-report-2019.pdf>. Accessed March 25, 2021.
2. Dougherty SH, Simmons RL. The biology and practice of surgical drains. Part 1. *Curr Probl Surg*. 1992;29:559–623.
3. Phillips BT, Wang ED, Mirrer J, et al. Current practice among plastic surgeons of antibiotic prophylaxis and closed-suction drains in breast reconstruction: experience, evidence, and implications for postoperative care. *Ann Plast Surg*. 2011;66:460–465.
4. Khan SM, Smeulders MJC, Van der Horst CM. Wound drainage after plastic and reconstructive surgery of the breast. *Cochrane Database Syst Rev* 2013;28:CD007258.
5. Tomita K, Yano K, Masuoka T, et al. Postoperative seroma formation in breast reconstruction with latissimus dorsi flaps: a retrospective study of 174 consecutive cases. *Ann Plast Surg*. 2007;59:149–151.
6. Paolini G, Sorotos M, Firmani G, et al. A simple method for quantitative assessment of suction drains. *Aesthetic Plast Surg*. 2020;44:1099–1101.
7. Bhavne MA (Khair). Can drains be avoided in lipo-abdominoplasty? *Indian J Plast Surg*. 2018;51:15–23.
8. Zhang H, Chen W, Mu L, et al. The distribution of lymph nodes and their nutrient vessels in the groin region: an anatomic study for design of the lymph node flap. *Microsurgery*. 2014;34:558–561.
9. Fang RC, Lin SJ, Mustoe TA. Abdominoplasty flap elevation in a more superficial plane: decreasing the need for drains. *Plast Reconstr Surg*. 2010;125:677–682.
10. Sadeghi A, Malata C. CASE REPORT persistent seromas in abdominal free flap donor sites after postmastectomy breast reconstruction surgery: case reports and literature review. *Eplasty*. 2013;13:e24.
11. Ozgok Kangal MK, Regan JP. Wound Healing. In: *StatPearls*. Treasure Island, Fla.: StatPearls Publishing; 2021.
12. Roland J. Is it serosanguinous or another type of wound drainage? Available at <https://www.healthline.com/health/serosanguinous>. Published 2017. Accessed March 20, 2021.
13. Swanson E. Prospective clinical study of 551 cases of liposuction and abdominoplasty performed individually and in combination. *Plast Reconstr Surg Glob Open*. 2013;1:e32.
14. Swanson E. Reducing seroma rates after abdominoplasty by avoiding electrodissection. *J Plast Reconstr Aesthet Surg*. 2015;68:864–865.
15. Rousseau P, Vincent H, Potier B, et al. Diathermocoagulation in cutting mode and large flap dissection. *Plast Reconstr Surg*. 2011;127:2093–2098.
16. Chen CF, Lin SF, Hung CF, et al. Risk of infection is associated more with drain duration than daily drainage volume in prosthesis-based breast reconstruction: a cohort study. *Medicine (Baltimore)*. 2016;95:e5605.
17. Barwell J, Campbell L, Watkins RM, et al. How long should suction drains stay in after breast surgery with axillary dissection? *Ann R Coll Surg Engl*. 1997;79:435–437.

18. Scevola S, Youssef A, Kroll SS, et al. Drains and seromas in TRAM flap breast reconstruction. *Ann Plast Surg.* 2002;48: 511–514.
19. Reid RR, Dumanian GA. A minimalist approach to the care of the indwelling closed suction drain: a prospective analysis of local wound complications. *Ann Plast Surg.* 2003;51: 575–578.
20. Murray JD, Elwood ET, Jones GE, et al. Decreasing expander breast infection: a new drain care protocol. *Can J Plast Surg.* 2009;17:17–21.
21. Clayton JL, Bazakas A, Lee CN, et al. Once is not enough: withholding postoperative prophylactic antibiotics in prosthetic breast reconstruction is associated with an increased risk of infection. *Plast Reconstr Surg.* 2012;130:495–502.
22. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. *Ann Surg.* 2008;248:189–198.
23. Association of Surgeons of Great Britain and Ireland. Guidelines for the implementation of enhanced recovery protocols. Available at http://www.improvement.nhs.uk/enhancedrecovery2/Portals/2/RAD1526_IIPP_Dec_09.pdf. Published 2009.