Fluid Resuscitation in Liposuction: A Retrospective Review of 89 Consecutive Patients

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Background: In 1998, the senior author presented the intraoperative fluid ratio, defined as the volume of super-wet solution and intraoperative intravenous fluid divided by the aspiration volume, to guide resuscitation fluid volumes in super-wet liposuction. The senior author demonstrated that intraoperative fluid ratios of 2.1 for small-volume and 1.4 for large-volume liposuction were safe and did not cause volume overload sequelae. A high urine output was common and reflected a mild overresuscitation, which could have adverse consequences in patients with undiagnosed cardiopulmonary disease. The purpose of this study was to compare overresuscitation sequelae in a cohort of consecutive super-wet liposuction patients using a new fluid management formula in which replacement fluid was given after 5000 cc of lipoaspirate instead of 4000 cc, as initially described.

Methods: The charts of 89 consecutive patients undergoing super-wet liposuction were retrospectively reviewed.

Results: The intraoperative fluid ratio was 1.8 for the small-volume reductions (<5000 cc, $n = 68$) and 1.2 (>5001 cc, $n = 21$) for the large-volume reductions. There were no episodes of pulmonary edema, congestive heart failure exacerbation, or other major complications. The average urine output in the operating room, the recovery room, and while on the floor was 1.5, 1.6, and 2.9 cc/kg/hour for the small-volume group and 1.7, 1.8, and 2.5 cc/kg/hour for the large-volume group.

Conclusions: The super-wet subcutaneous infiltration liposuction technique for both small- and large-volume reductions is safe and can be performed without adverse cardiopulmonary sequelae. Given the high urine outputs, the intraoperative fluid ratio can be further improved by possibly eliminating the replacement fluid altogether. (*Plast. Reconstr. Surg.* 117: 431, 2006.)

Liposuction is the most commonly performed aesthetic procedure in the United States.[1] It is generally safe, with low risks of major morbidity. As the volume of aspirate increases, however, so does the potential for extremes in fluid shifts, which may lead to hypovolemia or, more commonly, pulmonary edema and congestive heart failure.[1–6] In 1998, the senior author's group published the results of a prospective study analyzing the fluid management of 53 consecutive liposuction patients.[1] The recommendations from that study were as follows: (1) preoperative deficits should be replaced at the discretion of the surgeon and anesthesiologist; (2) maintenance crystalloid must be adjusted accordingly to vital signs and urine output; (3) super-wet infiltration is the technique of choice; and (4) replacement fluid should be given at 0.25 cc of intravenous fluid for each 1 cc of aspirate over 4000 cc. The intraoperative fluid ratio, the volume of intraoperative intravenous fluid plus super-wet solution divided by the aspiration volume, was maintained near 2.1 for small-volume liposuction (<4000 cc) and 1.4 for large-volume liposuction (>4001 cc). Intraoperative intravenous fluids included both maintenance fluids and replacement fluid. At these levels, there were no postoperative complications of congestive heart failure or pulmonary edema and no blood transfusions were required. The original study demonstrated the safety of the subcutaneous super-wet infiltration technique in liposuction by minimizing blood loss and preventing cardiopulmonary problems.

Although the fluid management strategy was successful in avoiding volume overload sequelae,

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patients appeared slightly overresuscitated, as demonstrated by their high urine output. In the patient with undiagnosed cardiopulmonary disease, this slight overresuscitation could be problematic. Therefore, to try to limit the degree of overresuscitation and limit the possibility of pulmonary edema or congestive heart failure, the intraoperative fluid ratio was modified. Replacement fluid was delivered at 0.25 cc crystalloid for each 1 cc over 5000 cc of aspirate, instead of 4000 cc as proposed in the initial study. We reviewed the experience of 89 consecutive patients undergoing liposuction with the revised intraoperative fluid ratio formula to determine whether mild overresuscitation could be minimized.

PATIENTS AND METHODS

The charts of the last 100 patients who underwent combined ultrasound-assisted and suction-assisted liposuction performed by the senior author (R.J.R.) were retrospectively reviewed. The dates of operation ranged from March of 1999 to April of 2002. Patients who underwent concomitant procedures were excluded from evaluation, leaving 89 patients who underwent only liposuction. The volume of aspirate was used to subdivide the patients reviewed into those who underwent small-volume (<5000 cc of aspirate) versus large-volume liposuction (>5001 cc of aspirate). Sixty-eight patients (76 percent of the study group) underwent small-volume liposuction and 21 patients (24 percent) underwent large-volume liposuction (Table 1). The average body mass index (weight in kg/[height in m]^2) was 23.3 (3.1) (SD) in the small-volume group and 25.9 (4.0) in the large-volume group.

Patients were marked preoperatively while standing, and preoperative photographs were used for liposuction planning. General endotracheal anesthesia was administered, with noninvasive blood pressure monitoring. Foley catheters were used at the discretion of either the surgeon or the anesthesiologist. Patients were positioned on the operating table in either the supine or prone position, depending on the area to be treated. A super-wet infiltration technique with 30 cc of 1% lidocaine, 1 cc of 1:1000 epinephrine, and 1 liter of lactated Ringer's crystalloid was used for the first 5 liters of infiltration. For infiltration volumes greater than 5 liters, the infiltration solution was made without lidocaine. In this study, the average ratio of infiltration to aspiration volume was 0.95. After adequate infiltration, suction-assisted liposuction was performed, with or without ultrasound-assisted liposuction.

The charts were reviewed for the intravenous fluid rate given in the operating room, the recovery room, and while on the floor. The intraoperative fluid ratio, defined as the volume of super-wet solution and intraoperative intravenous fluid divided by the aspiration volume, was calculated. The intraoperative fluid volume equaled the maintenance fluid volume and the replacement fluid volume. In this review, the replacement fluid volume was decreased from the original study such that 0.25 cc of intravenous fluid was given for each 1 cc of aspiration over 5000 cc, instead of 4000 cc. The use of a Foley catheter was recorded. Vital signs and urine output were evaluated intraoperatively, in the recovery room, and on the hospital floor. The length of the operation, time in the recovery room, and length of hospitalization were also recorded. Patient parenteral narcotic use was reviewed. Postoperative complications were noted.

Table 1. Study Group

	Volume Aspirated (cc)	No. of Patients (%)
Small-volume group	≤1000	12 (13%)
(n = 68)	1001–5000	56 (63%)
Large-volume group	5001-7000	15 (17%)
(n = 21)	>7000	6 (7%)
Total		89 (100%)

RESULTS

One hundred charts were evaluated. Patients undergoing concomitant procedures were excluded; 89 patients who underwent liposuction alone were included in this study. Patients were further subdivided by aspiration volumes. Sixty-eight patients underwent less than 5000 cc of aspiration and were considered small-volume reductions. Twenty-one patients underwent more than 5000 cc of aspiration and were considered large-volume reductions. All patients had at least 8 hours of preoperative fasting. No preoperative fluid boluses were given. Foley catheters were used in 53 percent of small-volume reductions and 100 percent of large-volume reductions.

Intraoperative Measurements

The average operating time was 1.7 hours for the small-volume group and 2.6 hours for the large-volume group. Intraoperative intravenous fluids were administered at an average rate of 10.2 cc/kg/hour for small-volume and 11.7 cc/kg/hour for large-volume reductions (Table 2). The average intraoperative fluid ratio was 1.8 (SD, 1.4) in the small-volume reductions and 1.2 (SD, 0.2) in the large reductions. The average urine output was 1.5 cc/kg/hour for the small-volume group and 1.7 cc/kg/hour for the large-volume group. Seventy-four percent of the small-volume group and 80 percent of the large-volume group had an intraoperative urine output greater than 1 cc/kg/hour.

Recovery Room Measurements

The average time spent in the recovery room was 1.8 hours for patients in the small-volume reduction group, and 1.5 hours for patients having large-volume reductions. The average intravenous fluid rate was 3.8 cc/kg/hour in the small-volume group and 4.4 cc/kg/hour in the large-volume group. The average urine output was 1.6 cc/kg/hour in the small-volume group and 1.7 cc/kg/hour in the large-volume group. Seventy-four percent of small-volume patients and 80 percent of large-volume patients had a urine output greater than 1 cc/kg/hour. There were no instances of pulmonary edema or congestive heart failure exacerbation.

Postoperative Measurements

The average intravenous fluid rate for patients on the floor was 1.6 cc/kg/hour in the small-volume group and 1.3 cc/kg/hour in the large-volume group. On average, intravenous fluids were required for only 10.5 hours postoperatively in the small-volume reduction group and 16.4 hours in the large-volume group. The average urine output was 2.9 cc/kg/hour in the small-volume group and 2.5 cc/kg/hour in the large-volume group (Table 2). One hundred percent of the small-volume patients had a urine output greater than 1 cc/kg/hour, compared with 95 percent of the large-volume group (Table 2). The one patient in the large-volume reduction group who had a urine output on the floor that was less than 1 cc/kg/hour had no recorded episodes of hypotension or tachycardia. Postoperative parenteral narcotics were discontinued on average after 4.9 hours in the small-volume group and 12.5 hours in the large-volume group. The average hospital stay was 15.5 hours in the small-volume group and 24 hours in the large-volume group. All of the small reduction patients were discharged on or before postoperative day 1. Of the large-volume group, six patients were discharged on postoperative day 2 and the remainder were discharged on the first postoperative day.

Complications

There were no major complications in this study. There were no episodes of congestive heart failure or pulmonary edema. No blood transfusions were necessary, and there were no pulmonary embolisms (Table 3).

DISCUSSION

Use of the super-wet subcutaneous technique in liposuction has greatly decreased blood loss during suction lipectomy and has minimized exposure of patients to blood transfusions. Although we have never experienced volume overload sequelae in treating more than 700 patients, it is a potential complication with the super-wet infiltration technique.

The University Texas Southwestern Medical Center's 1998 liposuction review presented the senior author's series of 53 liposuction patients.[1] From that article, the following recommendations for fluid management in the liposuction patient were developed: (1) preoperative fluid deficits should be given at the discretion of the surgeon or anesthesiologist; (2) maintenance fluids should be administered throughout the operation, with additional fluid boluses given at the discretion of the anesthesiologist, depending on the patient's vital signs and urine output; (3) a super-wet subcutaneous infiltration technique should be used; and (4) additional intraoperative replacement fluid should be given in the quantity of 0.25 cc of lactated Ringer's solution for every 1 cc of aspi-

Table 2. Intravenous Fluid Rates and Urine Output

Volume	Operating Room	Recovery Room	On the Floor
Intravenous fluid rate, cc/kg/hr			
Small	10.2 (3.6)	3.8 (3.4)	1.6 (0.9), n = 47
Large	11.7 (3.1)	4.4 (3)	1.3 (0.5), n = 20
Average urine output, cc/kg/hr (SD)			
Small	1.5 (1.0) (n = 35)	1.6 (1.2) (n = 39)	2.9 (1.2) (n = 39)
Large	1.7 (0.9) (n = 21)	1.7 (1.2) (n = 20)	2.5 (1.2) (n = 21)
Patients with urine output >1 cc/kg/hr, %			
Small	74% (n = 35)	77% (n = 39)	100% (n = 39)
Large	80% (n = 21)	80% (n = 20)	95% (n = 21)

Table 3. Durations

	Average Times (hours)		
Volume	Operating Room	Recovery Room	Length of Hospital Stay
Small	1.7 (0.7)	1.8 (1.0)	15.5 (9.1)
Large	2.6 (0.5)	1.5 (0.6)	24.1 (7.4)

ration over 4000 cc. By utilizing this technique, the senior author demonstrated safety in both small- and large-volume liposuction.

A new parameter with which to guide intraoperative fluid management in the liposuction patient was also presented in the 1998 article. The intraoperative fluid ratio was defined as the sum of the super-wet infiltration volume plus the intraoperative intravenous fluid volume divided by the volume of aspiration. In the University of Texas Southwestern study, the small-volume group (aspiration volume <4000 cc) had an intraoperative fluid ratio of 2.1, whereas that of the large-volume group (aspiration >4001 cc) was 1.4. With these ratios, it appeared that patients were mildly overresuscitated, since urine outputs were consistently high (>1 cc/kg/hour) throughout the hospitalization. Despite this mild overresuscitation, no patient in that study suffered adverse consequences of fluid overload. A similar result was found in the current study. The small-volume group had an intraoperative fluid ratio of 1.8, and that of the large-volume group was 1.2. The average urine output on the floor was 2.9 cc/kg/hour for the small-volume group and 2.5 cc/kg/hour for the large-volume group. As with the previous study, however, despite what appears to be a somewhat overresuscitation, there were no episodes of congestive heart failure or pulmonary edema. Maintaining an intraoperative fluid ratio at the levels used in this study is safe in the healthy patient (Figs. 1 through 3).

The intraoperative fluid ratio in this article was slightly less than that reported in the senior author's original review. This was as expected, since the replacement fluid was slightly decreased. Interestingly, this study did have slightly lower intraoperative and recovery room urine outputs in comparison to the 1998 study for both groups. The urine output on the floor, however, was greater in this study. We believe this represents a more physiologic postoperative urine output as surgical fluids are mobilized. It is reasonable to assume that a more gradual increase in urine output as the patient mobilizes the super-wet infiltration fluid and the intraoperative fluid is safer than abrupt rises in urine output, which was seen in the original study. In that review, the urine output for both groups peaked in the recovery room. It is reasonable to assume that this is more likely to adversely affect the patient with undiagnosed cardiopulmonary disease.

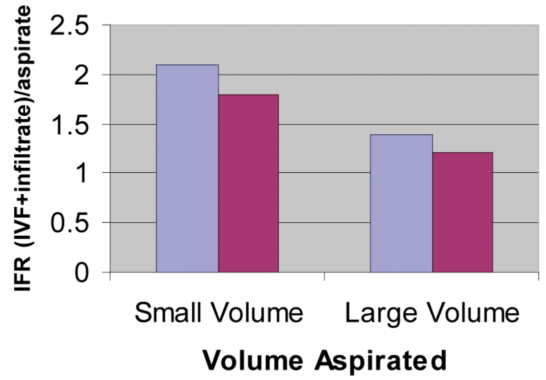

Fig. 1. Comparison of the intraoperative fluid ratio when utilizing the original (*blue*) and the revised (*purple*) formulas for both small- and large-volume liposuction.

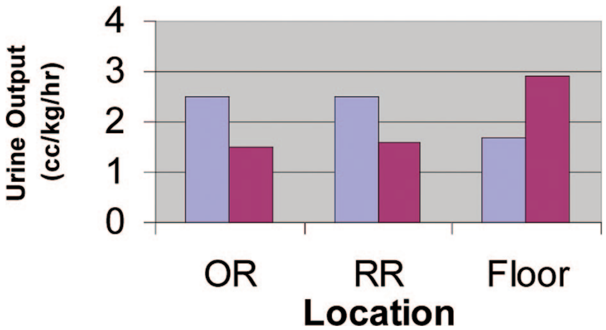

Fig. 2. Comparison of urine output in the small-volume liposuction group using the revised fluid management strategy (*purple*) and the original formulation presented in 1998 (*blue*). Data reprinted with permission.

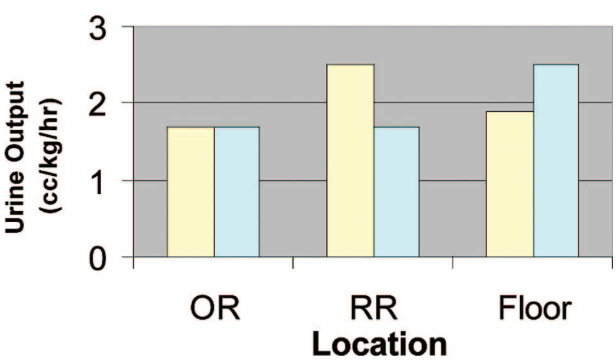

Fig. 3. Comparison of urine output in the large-volume liposuction group using the revised fluid management formula (*light blue*) and the original formula (*yellow*). Data reprinted with permission.

The revised fluid management strategy decreased the total volume of intraoperative fluid and early urine output, though the urine output on the floor were still high (2.9 cc/kg/hour and 2.5 cc/kg/hour for the small- and large-volume groups, respectively). This still reflects a mild degree of overresuscitation, and the potential exists for adverse volume overload sequelae. The fluid management strategy presented in this article can be improved, possibly by eliminating the replacement component of intraoperative fluids altogether, to minimize overresuscitation and concomitant cardiopulmonary complications.

CONCLUSIONS

Super-wet infiltration in liposuction is safe when fluid management is monitored carefully and adjusted to the patient's vital signs. Accordingly, by maintaining intraoperative fluid ratios near 1.8 for small-volume reductions and 1.2 for large-volume aspirations, the adverse consequences of fluid overload and can be avoided. The fluid management strategy presented in this article is an improvement from those previously published; however, the urine output in this study was still elevated, suggesting mild overresuscitation. Although there were no adverse complications of volume overload in this review, fluid management of the liposuction patient can be improved.

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REFERENCES

1. Trott, S. A., Beran, S. J., Rohrich, R. J., Kenkel, J. M., Adams, W. P., Jr., and Klein, K. W. Safety considerations and fluid resuscitation in liposuction: An analysis of 53 consecutive patients. *Plast. Reconstr. Surg.* 102: 2220, 1998.
2. Commons, G. W., Halperin, B., and Chang, C. C. Large-volume liposuction: A review of 631 consecutive cases over 12 years. *Plast. Reconstr. Surg.* 108: 1753, 2001.
3. Rohrich, R. J., Beran, S. J., and Fodor, P. B. The role of subcutaneous infiltration in suction-assisted lipoplasty: A review. *Plast. Reconstr. Surg.* 99: 514, 1996.
4. Grazer, F. M., and Meister, F. L. Complications of the tumescent formula for liposuction (Editorial). *Plast. Reconstr. Surg.* 100: 1893, 1997.
5. Grazer, F. M., and Meister, F. L. Factors contributing to adverse effects of the tumescent technique (surgical strategies). *Aesthetic Surg. J.* 17: 411, 1997.
6. Courtiss, E. H., Choucair, R. J., and Donelan, M. B. Large-volume suction lipectomy: An analysis of 108 patients. *Plast. Reconstr. Surg.* 89: 1068, 1992.