ONLINE FIRST

Effect of the Volume of Fluids Administered on Intraoperative Oliguria in Laparoscopic Bariatric Surgery

A Randomized Controlled Trial

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Objective: To determine whether intraoperative fluid management affects urine output in patients undergoing laparoscopic bariatric operations.

Design: Randomized controlled trial.

Setting: Academic tertiary referral center.

Patients: Morbidly obese patients scheduled to undergo laparoscopic bariatric procedures.

Interventions: Patients were randomly assigned to receive intraoperatively high (10 mL/kg/h, n=55) or low (4 mL/kg/h, n=52) amounts of Ringer lactate solution.

Main Outcome Measures: The primary end point was urine output. Secondary end points were postoperative creatinine serum concentration and complication rate.

Results: Significantly more fluids were administered intraoperatively to patients in the high-volume group compared with the low-volume group ($P<.001$). Regardless of the amount of fluids administered intraoperatively, low urine outputs (median [range], 100 [15-1050] mL in the high-volume group vs 107 [25-500] mL in the low-volume group; $P=.34$) were documented and were not significantly different. The mean creatinine serum concentration was within normal range at all times and was not significantly different between the groups ($P=.68$). The number of patients with complications was nonsignificantly lower in the low-volume group compared with the high-volume group (7 vs 10 patients, respectively; $P=.60$).

Conclusions: In patients undergoing laparoscopic bariatric surgery, intraoperative urine output is low regardless of the use of relatively high-volume fluid therapy. The results suggest that we should reconsider the common practice to administer intraoperative fluids in response to low urine output. Further studies are required to evaluate these data in other surgical patient populations.

Trial Registration: clinicaltrials.gov Identifier: NCT00753402

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ONE MAJOR ASPECT OF PERIoperative care is fluid management.[1] Urine output, a frequently determined clinical parameter, is among the factors that affect the amount of intraoperative fluid replacement. Intraoperative low diuresis often initiates several actions, among them the administration of intravenous fluids. Several studies suggested that the liberal administration of fluids in the perioperative period can adversely affect outcome.[2-6]

Surgery is the only effective treatment of morbid obesity, and it reduces mortality compared with conservative treatment.[7,8] Increased body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) has been shown to be an independent factor of perioperative onset of acute renal failure.[9] Nguyen et al[10] noted that because of the prolonged increase in intra-abdominal pressure during pneumoperitoneum in laparoscopic gastric bypass surgery, morbidly obese patients have low urine output intraoperatively. We therefore performed a randomized controlled trial in consecutive patients undergoing laparoscopic bariatric surgery with high-volume vs low-volume intraoperative fluid management.

See Invited Critique at end of article

We hypothesized that in patients undergoing laparoscopic bariatric operations, intraoperative fluid protocol (high vs low volume) would not affect urine output or perioperative renal function.

METHODS

PATIENTS

After institutional review board approval by Hadassah Hebrew University Medical Center, Jerusalem, Israel, and written informed patient consent, from May 1, 2008, to April 30, 2009, successive adult patients with an American Society of Anesthesiologists physical status of I through III who were presenting for laparoscopic bariatric surgery were prospectively studied. Patients were considered eligible if they had a BMI greater than 40 or had a BMI greater than 35 and at least 1 comorbid condition and were scheduled to undergo one of the following laparoscopic operations: Roux-en-Y gastric bypass, biliopancreatic diversion with duodenal switch, or sleeve gastrectomy. Patients younger than 18 years, patients with renal dysfunction (creatinine level >50% of the upper limit of the reference range) or congestive heart failure, and patients receiving diuretics were excluded from the study. After obtaining informed consent, patients were randomly assigned to 1 of 2 groups, the high-volume group (HVG) or low-volume group (LVG), using online randomization software.

SURGERY

The surgical team performed all types of surgical procedures and had broad experience in all techniques. Surgery was performed with the patients under general anesthesia in the reversed Trendelenburg position.

FLUID MANAGEMENT

Patients in the LVG received 4 mL/kg/h of Ringer lactate solution throughout the intraoperative period, whereas patients in the HVG received 10 mL/kg/h of Ringer lactate solution. No additional boluses of fluid were administered before skin incision, and all hemodynamic changes during this period were treated pharmacologically. Intraoperative fluid treatment of low blood pressure (<90 mm Hg or >20% below baseline) in both groups was guided by a fluid algorithm (**Figure 1**). Lost blood was replaced with Ringer lactate solution in a 3:1 volume replacement. Blood products were transfused according to the American Society of Anesthesiologists practice guidelines transfusion protocol.[11] The fluid regimen was continued until admission to the recovery room, where departmental routines ensued.

Operative time, urine output, and doses of drugs (vasopressors, furosemide) given during the surgical procedure were recorded.

POSTOPERATIVE MANAGEMENT

All patients were encouraged to stay out of bed in the evening of the operation and to walk on the first postoperative day. In the postoperative period, departmental routines guided fluid therapy. The routine in the general surgery department was as follows: patients were instructed to avoid consuming food and fluids until postoperative day 1, and a water-soluble contrast study was performed to verify the absence of anastomotic or staple-line leakage. If the study results proved negative, oral liquids were started the same day. The patients were advanced to a semiliquid diet on postoperative day 2, and they were instructed to maintain it until the end of the fourth postoperative week. All patients were treated with subcutaneous low-molecular-weight heparin, 0.5 mg/kg once daily, and pneumatic compression stockings until discharge. Antibiotics were continued for 24 hours after the operation. Postoperative follow-up included recording of the volumes of crystalloids administered intravenously in the first 3 postoperative days and the number of units of blood and blood products (if given) until hospital discharge. The fluid and food consumed each day were recorded. Oxygen saturation, hematocrit, and potassium, sodium, blood urea, and serum creatinine concentrations were also measured in the first 3 postoperative days and before discharge. All measurements were made in the morning. Additional blood tests, electrocardiography, and measurements of cardiac enzymes were performed when clinically indicated. Postoperatively, all patients were examined and interviewed daily. Complications detected by the examining physician, who was not aware of the patient's group assignment, were recorded. Readmissions and the cause for readmission until 30 days postoperatively were also recorded. Postoperative visits were scheduled for 2 weeks and 1 month following hospital discharge.

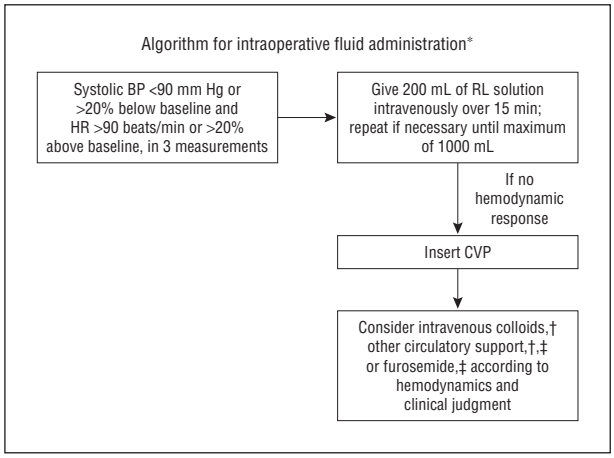

Figure 1. Algorithm for intraoperative fluid administration. *Indications for blood transfusion are listed in the text. †Central venous pressure (CVP) lower than 15 mm Hg; ‡CVP higher than 15 mm Hg. BP indicates blood pressure; HR, heart rate; and RL, Ringer lactate.

OUTCOME MEASURES

The primary end point was intraoperative urine output. Secondary end points were serum creatinine concentrations in the first 3 postoperative days. Another secondary end point combined the number of patients who died and those who developed complications during the perioperative period. Only those complications that could have affected patient outcome were included (surgical, anesthetic, cardiovascular, cerebral, renal, and infectious). Data were collected and analyzed by bedside clinicians and investigators blinded to patients' group assignment.

COMPLICATIONS

Postoperative bleeding was regarded as significant if there was a need for blood transfusion or reoperation. Intra-abdominal abscess (diagnosed by ultrasonography or computed tomography) and anastomotic leakage were considered complications when drainage or reoperation was needed. Anastomotic stricture was considered a complication when endoscopic dilation was indicated and performed. Wounds were considered

Table 1. Patient Characteristics

Characteristic	HVG (n=55)	LVG (n=52)	*P* Value
Sex, No.			.69
Male	18	19	
Female	37	33	
Age, mean (SD) [range], y	41.6 (13.0) [19-72]	39.9 (13.0) [18-62]	.50
BMI, mean (SD) [range]	43.1 (4.9) [35.0-59.7]	43.6 (5.0) [35.0-56.0]	.58
ASA physical status, No.			.55
II	38	33	
III	17	19	
Hyperlipidemia, No. (%)	26 (47)	24 (46)	>.99
Hypertension, No. (%)	19 (34)	20 (38)	.83
Obstructive sleep apnea, No. (%)	17 (31)	15 (29)	.83
Type 2 diabetes mellitus, No. (%)	15 (27)	13 (25)	.83
Ischemic heart disease, No. (%)	5 (9)	6 (11)	.76
Smoking, No. (%)	11 (20)	8 (15)	.62
Pulmonary disease, No. (%)	2 (4)	2 (4)	>.99

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); HVG, high-volume group; LVG, low-volume group.

Table 2. Surgical Data

Variable	HVG (n=55)	LVG (n=52)	*P* Value
Type of surgery, No. (%)			
LRYGB	31 (56)	26 (50)	.56
LSG	20 (36)	18 (35)	>.99
LDS	4 (8)	8 (15)	.23
Duration of surgery, mean (SD), min[a]	187 (61)	194 (73)	.56
Baseline mean arterial pressure, mean (SD), mm Hg	77 (13)	81 (11)	.53
Baseline heart rate, mean (SD), beats/min	72 (11)	76 (12)	.55
Total volume of fluid administered, median (range), mL	3300 (1500-14 000)	1325 (480-3100)	<.001
Administration to patients, No. (%)			
Bolus of fluids[b]	2 (4)	16 (31)	<.001
Hydroxyethyl starch, 6%	0	0	NA
Blood transfusion	0	1	.49
Blood products	0	1	.49
Ephedrine	2	7	.06
Intraoperative urine output, median (range), mL	100 (15-1050)	107 (25-500)	.34

Abbreviations: HVG, high-volume group; LDS, laparoscopic biliopancreatic diversion with duodenal switch; LRYGB, laparoscopic Roux-en-Y gastric bypass; LSG, laparoscopic sleeve gastrectomy; LVG, low-volume group; NA, not applicable.
[a] Including anesthesia time.
[b] As indicated by the fluid algorithm.

infected when pus could be expressed from the incision or aspirated from a loculated mass within the wound. Diagnosis of pneumonia required new infiltrate on chest radiography combined with 2 of the following: temperature higher than 38°C, leukocytosis, and positive sputum culture. Urinary tract infection was diagnosed when symptoms consistent with the diagnosis prompted urinary analysis that showed bacterial counts greater than 100 000 colony-forming units and positive culture. Diagnosis of sepsis required bacterial infection and at least 2 of the following clinical signs: either hypothermia or hyperthermia, tachycardia, and tachypnea and leukocytopenia or leukocytosis. Diagnosis of myocardial infarction required an elevation of the creatine kinase MB fraction isoenzyme or troponin T concentration above the hospital laboratory's myocardial infarction threshold and either new Q waves or persistent changes in the ST-T segment. Congestive heart failure and pulmonary edema were defined by clinical and radiological signs that required a change in medication involving at least treatment with diuretic drugs. Arrhythmias required 12-lead echocardiogram confirmation. Neurological symptoms, presumably from a vascular cause, lasting less than 24 hours were defined as transient ischemic attack. Cerebrovascular accident was diagnosed when there was a new focal neurological deficit of presumed vascular cause persisting longer than 24 hours with a neurological imaging study that did not indicate a different cause. A diagnosis of acute respiratory distress syndrome was established when there was an acute onset of respiratory distress, evidence on chest radiographs of airspace changes in all 4 quadrants, ratio of P_{O_2} to inspired fraction of oxygen of less than 200, and pulmonary artery wedge pressure less than 18 mm Hg or no clinical evidence of left atrial hypertension. Pulmonary embolism was diagnosed only after evidenced by spiral computed tomography. Renal dysfunction was defined by a creatinine concentration greater than 50% of the upper limit of the normal values.

STATISTICAL ANALYSIS

Categorical data were analyzed using the χ^2 test or Fisher exact test. Differences between the means or medians of the 2 groups were compared using the *t* test and the Mann-Whitney *U* test, respectively. Data within each group were analyzed using analysis of variance for repeated measurements. When appropriate, post hoc analyses were performed with the Tukey test. Exact confidence intervals were computed for the overall rate of complications. Analysis was performed using SAS version 6.12 statistical software (SAS Institute, Inc, Cary, North Carolina). Results are expressed as mean (SD) or median (range). A minimum sample size of 78 patients was calculated to detect a difference between the groups in primary outcome (ie, intraoperative urine output) of 40 mL, with power of 80% assuming an SD of 120 mL and 2-sided $P<.05$.

RESULTS

DEMOGRAPHIC AND SURGICAL DATA

One hundred seven patients were enrolled in the study, 55 in the HVG and 52 in the LVG. Demographic and surgical data are listed in **Table 1** and **Table 2**. Randomization was successful in achieving comparable groups for all characteristics listed, including sex, age, BMI, American Society of Anesthesiologists physical status, and percentage of patients with concomitant diseases. The most prevalent surgery performed was laparoscopic Roux-en-Y gastric bypass. The duration of surgery was not significantly different between the groups ($P=.56$). Central venous pressure was not inserted for the purpose of guiding fluid management according to the study algo-

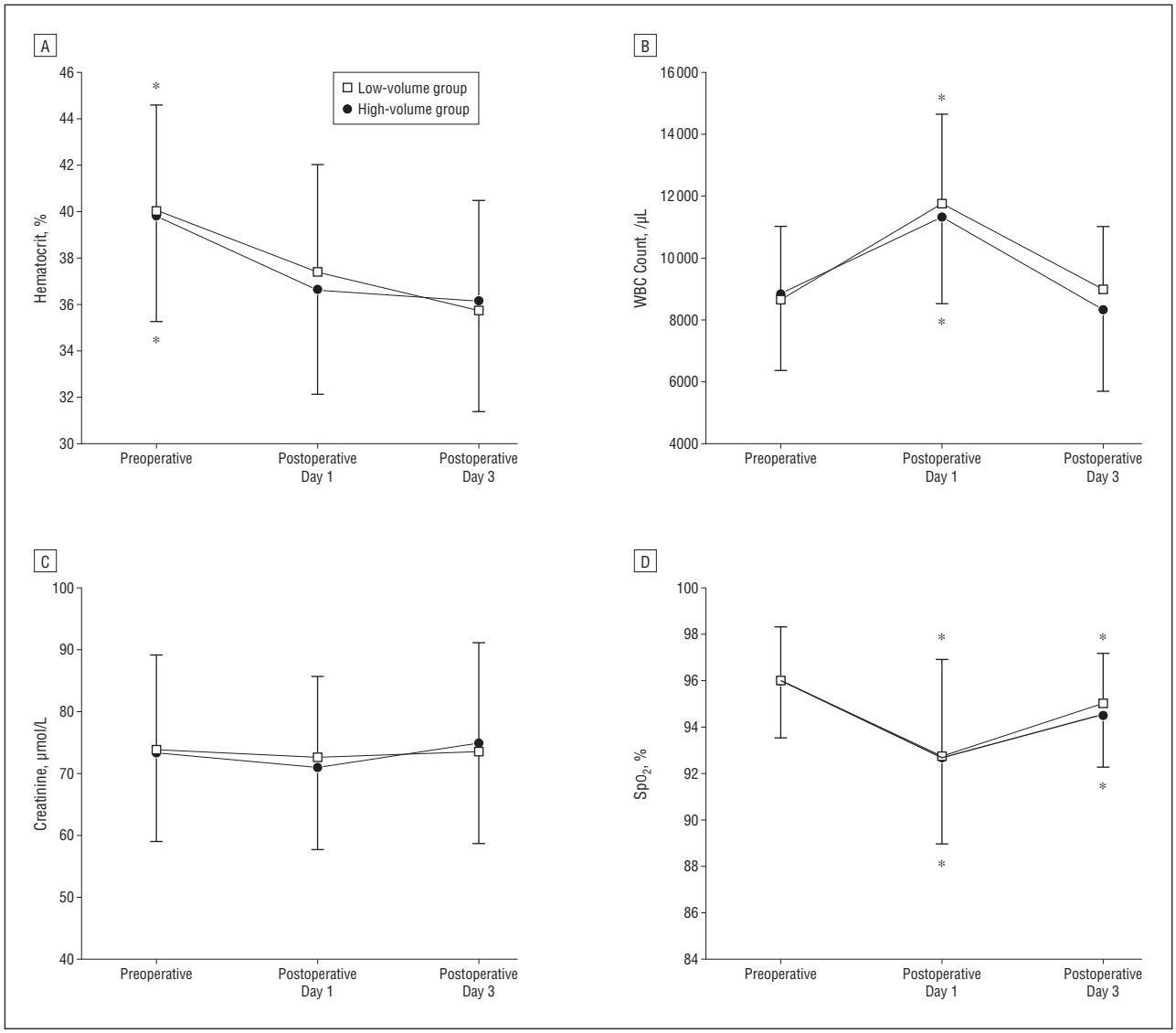

Figure 2. Perioperative laboratory and oxygen saturation data including hematocrit (A), white blood cell (WBC) count (to convert to $\times 10^9$ per liter, multiply by 0.001) (B), serum concentration of creatinine (to convert to milligrams per deciliter, divide by 88.4) (C), and oxygen saturation as measured by pulse oximetry (Spo_2) (D) in the preoperative period (the day before surgery) and postoperative days 1 and 3. Values are expressed as mean (SD). $*P < .05$ compared with the other 2 measurements in the same group.

rithm. Tracheal extubation was accomplished in all patients in the operating theater.

FLUID BALANCE

Significantly more fluids were administered intraoperatively to patients in the HVG compared with the LVG (median [range], 3300 [1500-14 000] vs 1325 [480-3100] mL, respectively; mean [SD], 32 [15] vs 13 [4] mL/kg, respectively; mean [SD], 10.3 [2.8] vs 4.3 [1.5] mL/kg/h, respectively; mean [SD], 1012 [387] vs 443 [165] mL/h, respectively; $P < .001$) (Table 2). Regardless of the amount of fluids administered intraoperatively, low urine outputs were documented and were not significantly different between the HVG and LVG (median [range], 100 [15-1050] vs 107 [25-500] mL, respectively; mean [SD], 31 [47] vs 32 [42] mL/h, respectively; $P = .34$). The majority of patients in both groups (87% in the HVG and 89% in the LVG) had intraoperative urine output lower than 0.5 mL/kg/h. Compared with the HVG, significantly more patients in the LVG had episodes of hypotension that were treated with fluid boluses in accordance with the fluid algorithm (Figure 1). Intraoperative blood and blood product transfusions were not significantly different between the groups (both $P = .49$). Only 1 patient from the LVG received blood and blood products during the operation. Postoperatively, the mean amount of fluid administered was similar among the groups (data not shown).

LABORATORY DATA

Preoperative creatinine serum levels, hematocrit, white blood cell count, and arterial oxygen saturation were similar in both groups (**Figure 2**). The mean creatinine serum concentrations were within the reference range at all times and were not significantly different between the groups at all times. In the immediate post-

Table 3. Perioperative Complications and Readmission Within 30 Days of Hospital Discharge[a]

Complication	HVG		LVG	
	Patients, No.	Treatment (No. of Patients)	Patients, No.	Treatment (No. of Patients)
Perioperative bleeding	2	Operation (1), blood transfusion (1)	2	Operation (1), blood transfusion (1)
Intra-abdominal abscess, staple-line leakage, or anastomotic leakage	3	Percutaneous drainage (2), operation (1)	2	Percutaneous drainage (2)
Anastomotic stricture or sleeve narrowing	2	Endoscopic dilation	1	Endoscopic dilation
Splenic infarction	0		1	Symptomatic
Wound infection	0		1	Antibiotics and drainage
Urinary tract infection	1	Antibiotics	0	
TIA	1	Anticoagulation	0	
Renal dysfunction	1	Rehydration	0	

Abbreviations: HVG, high-volume group; LVG, low-volume group; TIA, transient ischemic attack.
[a]There were a total of 10 complications in 10 patients (18%) in the HVG and 7 complications in 7 patients (13%) in the LVG ($P = .60$); there were 7 readmissions in the HVG and 7 readmissions in the LVG ($P > .99$).

operative period (first and third postoperative days), hematocrits decreased significantly in both groups ($P < .001$) and were not different among the groups. White blood cell counts increased significantly on the first postoperative day in both groups but returned to baseline (the preoperative value) on postoperative day 3. Postoperative oxygen saturation decreased significantly on the first postoperative day. It increased on the third postoperative day; however, it did not reach baseline values. Values were not different between groups at all times.

CLINICAL COURSE, COMPLICATIONS, AND READMISSION RATE

No patients died during the perioperative period. Complications developed in 10 patients (18%) in the HVG and 7 patients (13%) in the LVG ($P = .60$) (**Table 3**). The only case of renal dysfunction occurred in a patient in the HVG 2 weeks after laparoscopic sleeve gastrectomy. The mean (range) length of hospital stay was 4 (2-21) days in the HVG and 4 (2-29) days in the LVG ($P > .05$). The time until the patient resumed drinking and consumed soft food was also not significantly different between the groups (data not shown).

The readmission rate within 30 days of discharge was similar (13%) in both groups (Table 3). The main causes for readmission were stricture and intra-abdominal abscess or leakage.

COMMENT

The major findings of our study in morbidly obese patients undergoing laparoscopic bariatric surgery are the following. First, intraoperative oliguria occurs, and it is not associated with postoperative renal dysfunction. Second, the amount of fluid administered intraoperatively, in the range of 4 to 10 mL/kg/h, has no effect on urine output. Third, the complication rate in patients treated with a low-volume fluid regimen was nonsignificantly lower than that in patients treated with a high-volume regimen.

INTRAOPERATIVE FLUID ADMINISTRATION, URINE OUTPUT, AND RENAL FUNCTION

It is devastating to both patients and treating physicians when patients, with no evidence of renal dysfunction preoperatively, develop renal failure after surgery. Perioperative onset of renal failure in patients with previously normal renal function is associated with increased postoperative mortality.[9] Moreover, increased BMI has been shown to be an independent factor of perioperative onset of renal failure.[9] Strategies to avoid such a major complication remain controversial.[12] Prerenal acute tubular necrosis has long been thought to be a prominent cause of postoperative renal dysfunction.[13] As a result, surgeons and anesthesiologists attempt to maintain renal blood flow by a variety of strategies such as intravenous hydration, control of blood pressure, and administration of vasoactive substances. Intraoperative urine output is thus watched closely as one measure of success with this goal, in both clinical practice and studies that use fluid algorithms.[5,6,14] Intraoperative reduced urine output, however, may not reflect fluid status or predict future renal failure.[9] Indeed, reduced diuresis is reported during bariatric and nonbariatric laparoscopic operations and is not associated with impaired renal function.[10,15-17] Possible mechanisms include a direct pressure effect of pneumoperitoneum on the renal vasculature, resulting in reduced renal blood flow, and the intraoperative releases of certain stress hormones.[15] The current randomized trial extends previous data by showing that regardless of the volume of crystalloids administered, in the range of 4 to 10 mL/kg/h, urine output remains similarly low while renal function is preserved. This suggests that limiting the total crystalloids administered is tolerable and may even prove to be beneficial (discussed later). Recently, in a comprehensive review, Hahn[18] summarized his and others' work regarding fluid kinetics in the conscious patient vs the anesthetized patient. Using a volume kinetics method for analyzing and simulating the distribution and elimination of infusion fluids, he showed that the clearance of fluids during general anesthesia is

only a small fraction of that observed in conscious volunteers[19-21] and is even lower during laparoscopy.[22,23] Thus, only a limited volume of urine will be produced regardless of how much fluid is infused. These data suggest that urine output in anesthetized patients may not be an adequate indicator of fluid balance. Also, the recommendation used by most investigators that includes the need to keep a balanced approach to intraoperative fluid management with fluids administered to maintain, among other things, urine output of at least 0.5 mL/kg/h should be reconsidered.[1,2,24]

INTRAOPERATIVE FLUID APPROACH IN OBESE PATIENTS UNDERGOING LAPAROSCOPIC BARIATRIC SURGERY

Obese patients have their own unique set of challenges. Systematic knowledge regarding the ideal fluid approach for laparoscopic bariatric surgery is lacking. Most studies of morbidly obese patients undergoing surgery do not comment on the amount of fluids administered, while others draw conclusions that are not evidence based. For example, based on their experience with morbidly obese patients in bariatric surgery, Ogunnaike et al suggested that "intraoperative fluid requirements are usually larger if postoperative acute tubular necrosis is to be prevented. Patients usually require up to 4 to 5 L of crystalloid for an average 2-hour operation."[25] On the other hand, a group from the Mayo Clinic College of Medicine[26] summarized their experience of fluid management during bariatric procedures and concluded that a relatively restricted-volume therapy reduced the incidence of postoperative pulmonary dysfunction and hypoxia and shortened hospital stays. In a retrospective analysis of morbidly obese patients undergoing laparoscopic surgery, Schuster et al[27] noted that patients who received approximately 5 mL/kg/h of fluids (vs approximately 6 mL/kg/h) had a higher incidence of nausea and vomiting. Recently, Wool et al[17] reported that regardless of the amount of intraoperative fluids administered (15 mL/kg vs 40 mL/kg), the incidence of rhabdomyolysis was similar. Our study extends the current limited data by showing that the administration of relatively liberal volumes of fluids does not necessarily improve outcome. On the contrary, we found a tendency toward a reduced complication rate in the LVG. Thus, small volumes of fluids may benefit the patient without adversely affecting renal function. As the complication rate was a secondary end point, sample size was not adequately set to test this parameter. The data thus call for a larger trial that will further explore the important issue of fluid management in morbidly obese patients undergoing bariatric operations.

STUDY LIMITATIONS

The study was not conducted in a totally blinded fashion. The anesthesiologist treating the patient in the intraoperative period was not blinded to the patient's group assignment; however, the indications for additional fluid administration were standardized. Moreover, postoperative adverse outcomes were detected by the examining physician, who was not aware of the patient's assignment. Another limitation is that our study evaluated only 2 volumes of fluids.

CONCLUSIONS

When considering perioperative fluid management, it is important to reach a balance between giving too little fluid, with consequent hypovolemia and organ dysfunction, or too much fluid, with resulting collateral damages such as edema and organ injury. In morbidly obese patients undergoing a variety of laparoscopic bariatric operations, we used 2 different approaches: in the LVG, timely replacement of fluids was applied (additional fluid boluses were given during the operation as indicated); in the HVG, patients were given relatively large amounts of fluids a priori. In both treatment arms, however, urine output was not an indicator for additional fluid administration. The results of the study suggest that oliguria during laparoscopic bariatric surgery is unresponsive to fluid administration. As intraoperative oliguria does not result in clinically significant renal dysfunction, the routine to administer more fluids to enhance diuresis during these operations is futile. On the contrary, low-volume management might be beneficial in terms of outcome as some previous studies in other surgical scenarios have suggested. Additional studies are needed to establish the role of urine output as an indicator for fluid administration in the perioperative period in other surgical patient populations.

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Author Contributions: Dr Matot takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Matot, Elazary, and Keidar. *Acquisition of data:* Paskaleva, Eid, Cohen, Khalaileh, Elazary, and Keidar. *Analysis and interpretation of data:* Matot, Paskaleva, and Keidar. *Drafting of the manuscript:* Matot, Paskaleva, Eid, Cohen, Khalaileh, and Keidar. *Critical revision of the manuscript for important intellectual content:* Matot, Elazary, and Keidar. *Statistical analysis:* Matot and Elazary. *Obtained funding:* Matot. *Administrative, technical, and material support:* Matot, Paskaleva, Eid, Cohen, Khalaileh, Elazary, and Keidar. *Study supervision:* Matot, Elazary, and Keidar.
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INVITED CRITIQUE

Is My Patient Wet or Dry? Should My Patient Be Wet or Dry?

A First Step in Answering These Queries

There have been remarkable advances in anesthetic care in the last several decades. However, the recommendation to use urine output (0.5 mL/kg of body weight) to guide intraoperative fluid administration is rarely challenged. This study by Matot et al[1] is an important contribution to the literature. Matot and colleagues convincingly suggest that patients undergoing laparoscopic gastric bypass are oliguric regardless of the amount of fluid administered. Furthermore, their data suggest that the cohort receiving less fluid may have better outcomes.

What guidelines should we use to direct fluid administration during major operations? There are few. The most thorough review of the literature was completed by the Association of Surgeons of Great Britain and Ireland and published as the "British Consensus Guidelines on Intravenous Fluid Therapy for Adult Surgical Patients."[2] This comprehensive document included only *one* recommendation for intraoperative fluid administration: "In patients undergoing some forms of . . . abdominal surgery, intraoperative treatment with intravenous fluid to achieve an optimal value of stroke volume should be used where possible. . . . "[2] The few studies referenced included randomized trials that used volume expanders (eg, 6% hetastarch) to optimize stroke volume based on intraoperative transesophageal Doppler examination findings.[3] In one study, the treatment arm (with more fluid) had earlier return of bowel function, less nausea and vom-