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# Fluids in the postoperative period: effects of lack of adjustment to body weight

## *Líquidos en el período postoperatorio: efectos de la falta de ajuste al peso corporal*

## *Fluidos no período pós-operatório: efeitos da falta de ajuste ao peso corpóreo*

**ABSTRACT**

**Objective:** To compare the differences in fluid and electrolyte balance in patients with low and high weight in the first postoperative day.

**Methods:** Over a period of 18 months, we prospectively evaluated 150 patients in the first 24 hours after surgery, in a university-affiliated hospital intensive care unit. Patients with low weight (≤ 60 kg) and high body weight (≥ 90 Kg) were compared in terms of fluid intake and output.

**Results:** No significant differences were observed in the volume (4334 ± 1097 vs. 4644 ± 1957 ml/24 h) and composition of the fluids administered (481 ± 187 vs. 586 ± 288 mEq $[Na^+]_{administered}$/24 h). The 24 h urine output was similar (2474 ± 1597 vs.2208 ± 678 ml/24 h) but low weight group showed higher electrolyte elimination (296 ± 195 vs.192 ± 117 mEq $[Na^+]_{urine}$/24 h, p = 0.0246). When the administered fluids were adjusted for body weight, the volume and amount of electrolytes of fluids administered were higher in the low weight group (79 ± 21 vs. 47 ± 22 ml/kg/24 h, p<0.0001 and 8.8 ± 3.4 vs. 5.8 ± 3.3 mEq $[Na^+]_{administered}$/kg/24 h, p=0.017, respectively). This group also showed higher urine output and electrolyte elimination (45 ± 28 vs. 22 ± 7 ml/kg/24 h, p = 0.0002 and 5.3 ± 3.5 vs. 1.8 ± 1.2 mEq $[Na^+]_{urine}$/kg/24 h, p<0.0001, respectively).

**Conclusions:** The lack of adjustment of the fluid therapy to body weight determined that low weight patients received more fluid than high weight patients according to their body weight. This fluid overload could be compensated by increased urine output and electrolyte elimination.

**Keywords:** Fluid therapy; Electrolytes; Postoperative period; Body weigth

## INTRODUCTION

The perioperative fluid management is controversial because of the limited and contradictory data available from randomized trials. More than fifty years ago, opposite opinions arose about this topic. First, Moore recommended restrictive fluid therapy based on the fact that the surgical trauma produces endocrine and metabolic effects leading to renal water and sodium conservation.(1) In contrast, Shires argued that the frequent hypovolemia resulting from fluid redistribution to third spaces should be replaced by additional solutions.(2) Moreover, Shoemaker lately introduced the concept of supranormal resuscitation, which was performed primarily by the use of fluid infusions and inotropes.(3) Recently, more balanced approaches claimed for the individualization

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of fluid therapy in elective surgery.[4] Therefore, the administration of fluids should consider the extent of the surgical procedure as well as the patient's characteristics in order to maintain tissue perfusion. Excessive fluid administration could produce tissue edema but insufficient hydration could induce tissue hypoperfusion. Both situations are associated to the development of organ failures and worsened outcome. In addition, these concerns remain in the postoperative period. Besides, the knowledge about the fluid management in this period is still poorer.

Despite the debate about the beneficial and detrimental effects of the so-called "liberal" and "restrictive" strategies, neither the criteria nor the type of body weight (actual or predicted) used for adjusting these therapeutic behaviors has been clearly established. For example, in intraoperative studies, the range of liberal regimens was 2750-5388 ml. On the contrary, restrictive protocols used 998-2740 ml.[5,6] As a matter of fact, there was an overlapping between the criteria used in some studies.[7,8] In postoperative studies, the reported ranges were 1500-2900 and 500-2100 ml for liberal and restrictive behaviors, respectively.[5,6,9]

Nevertheless, the amount of fluids administered was not adjusted to body weight in most of those studies. Therefore, our goal was to compare the administration of fluid and electrolytes, in the first postoperative day, between low and high weight patients. Our hypothesis was that our therapeutic behaviors unintentionally result in the administration of larger amounts of fluids in low weight patients compared to high weight patients because of the lack of consideration of patients' weight.

## METHODS

**Design:** Prospective observational study.

**Setting:** Medical-surgical intensive care unit (ICU) at teaching hospital. The ICU has 16 beds.

**Patients:** Over a period of 18 months (01/03/08 to 01/09/09), 150 patients were evaluated postoperatively in the first 24 hours after surgery. We selected patients with an actual weight ≤ 60 and ≥ 90 kg who were assigned to low weight and high weight groups, respectively.

This study was approved by the Institutional Ethics Committee. Since applied procedures were part of the usual diagnostic management, informed consent was waived.

**Measurements:** On admission and at 24 h, demographic data (age, gender) were recorded. Acute Physiologic Chronic Health Evaluation (APACHE) II score,[10] predicted risk of mortality, and Sepsis-related Organ Failure Assessment (SOFA) score[11] were calculated. Shock was defined as the need of vasopressor drugs to maintain a mean arterial blood pressure ≥ 65 mm Hg. We considered that patient were on mechanical ventilation if it was required in the ICU, at any time during the first 24 h after surgery.

Arterial blood samples were analyzed for gases and electrolytes ([$Na^+$], [$K^+$], and [$Cl^-$]), and blood chemistry on admission and after 24 h. Urine electrolytes were also measured. The volume and composition of the fluids administered as well as the urine output during the first 24 h was registered. Fluids and electrolytes balances were calculated and adjusted to actual weight. The body weight was measured in the pre-operatory evaluation.

We excluded patients with renal failure (serum creatinine > 1.7 mg%), bladder surgery, younger than 18-year old, and those with incomplete records of balances.

**Data analysis:** Patients were grouped according their body weight in low (≤ 60 kg) and high (≥ 90 Kg) weight groups. Data, expressed as media ± standard deviation, median [25th-75th percentiles], or percent, were compared with test *t* or Mann Whitney *U* test for unpaired samples, and *chi* square test for categorical variables. A p value < 0.05 was considered statistically significant.

## RESULTS

Table 1 shows the clinical and epidemiologic characteristics of the patients. There was a lower proportion of men in the low weight group. Although SOFA and APACHE II scores were similar, there were more patients on mechanical ventilation in the low weight group (Table 1).

No significant differences were observed in the volume and composition of the fluids administered. The 24 h urine output was similar but low weight group showed higher electrolyte elimination and lower plasma urea, creatinine, and albumin levels (Table 2).

When the fluids were adjusted for body weight, the volume and amount of electrolytes of the fluids administered were higher in the low weight group.

**Table 1 - Clinical and epidemiologic characteristics of the patients**

| | Low weight | Height weight | p value |
|---|---|---|---|
| Number of patients | 29 | 26 | |
| Actual weight (kg) | 55 ± 5 | 101 ± 16 | 0.0001 |
| Gender, male | 1 (3) | 18 (75) | 0.0001 |
| Age (years) | 59 ± 23 | 64 ± 12 | 0.38 |
| Type of surgery | | | |
| Emergency | 9 (31) | 4 (15) | 0.17 |
| Abdominal | 13 (45) | 15 (58) | 0.34 |
| Orthopedic | 9 (31) | 3 (12) | 0.0805 |
| Pulmonary | 2 (7) | 5 (19) | 0.17 |
| Urologic | 0 (0) | 3 (12) | 0.0599 |
| Neurologic | 2 (7) | 0 (0) | 0.17 |
| Gynecologic | 2 (7) | 0 (0) | 0.17 |
| Vascular | 1 (3) | 0 (0) | 0.34 |
| APACHE II score | 9.2 ± 5.4 | 8.5 ± 3.6 | 0.59 |
| SOFA score | 2.4 ± 2.5 | 1.5 ± 2.2 | 0.15 |
| Mechanical ventilation | 9 (31) | 1 (4) | 0.0128 |
| Shock | 7 (24) | 2 (8) | 0.10 |
| ICU length of stay (days) | 3 [2-7] | 2 [2-4] | 0.18 |
| Hospital length of stay (days) | 8 [6-17] | 7 [5-10] | 0.20 |
| ICU and hospital mortality (%) | 2 (7) | 0 (0) | 0.17 |
| APACHE II predicted mortality | 12 ± 9 | 10 ± 5 | 0.27 |

ICU – intensive care unit; APACHE - Acute Physiologic Chronic Health Evaluation; SOFA - Sequential Organ Failure Assessment. Results are expressed in mean ± standard deviation or number (%).

**Table 2 - Fluid and electrolyte balance in the first postoperative 24 h**

| | Low weight | Height weight | p value |
|---|---|---|---|
| Fluid administered (ml/24 h) | 4334 ± 1097 | 4644 ± 1957 | 0.46 |
| $[Na^+]_{administered}$ (mEq/24 h) | 481 ± 187 | 586 ± 288 | 0.18 |
| $[K^+]_{administered}$ (mEq/24 h) | 56 ± 30 | 62 ± 25 | 0.25 |
| $[Cl^-]_{administered}$ (mEq/24 h) | 507 ± 181 | 603 ± 62 | 0.13 |
| Urine output (ml/24 h) | 2474 ± 1597 | 2208 ± 678 | 0.44 |
| $[Na\ ]_{urine}$ (mEq/24 h) | 296 ± 195 | 192 ± 117 | 0.0246 |
| $[K^+]_{urine}$ (mEq/24 h) | 88 ± 47 | 93 ± 41 | 0.73 |
| $[Cl^-]_{urine}$ (mEq/24 h) | 320 ± 210 | 223 ± 119 | 0.0487 |
| $Urea_{plasma}$ on admission (mg%) | 29 ± 12 | 40 ± 16 | 0.004 |
| $Urea_{plasma}$ at 24 h (mg%) | 27 ± 13 | 39 ± 20 | 0.008 |
| $Creatinine_{plasma}$ on admission (mg%) | 0.7 ± 0.2 | 1.1 ± 0.4 | 0.0002 |
| $Creatinine_{plasma}$ at 24 h (mg%) | 0.8± 0.3 | 1.1 ± 0.3 | 0.0004 |
| $Albumin_{plasma}$ on admission (g%) | 3.0 ± 0.7 | 3.7 ± 0.5 | 0.003 |
| $Albumin_{plasma}$ at 24 h (g%) | 3.0 ± 0.6 | 3.4 ± 0.5 | 0.007 |

Results are expressed in mean ± standard deviation.

This group also showed higher urine output and electrolyte elimination (Table 3).

After 24 h, there were trends in both groups to decreased hemoglobin levels (only significant in the high weight group) and improved pH, $[HCO_3^-]$, base excess and lactate (table 4). At 24 h, arterial lactate was slightly but significantly higher in the high weight group.

**Table 3 - Weight-adjusted fluid therapy and urine output and composition**

| | Low weight | Height weight | p value |
|---|---|---|---|
| Fluid administered (ml/kg/24 h) | 79 ± 21 | 47 ± 22 | 0.000001 |
| $[Na^+]_{administered}$ (mEq/kg/24 h) | 8.8 ± 3.4 | 5.8 ± 3.3 | 0.017 |
| $[K^+]_{administered}$ (mEq/kg/24 h) | 1.0 ± 0.6 | 0.6 ± 0.3 | 0.003 |
| $[Cl^-]_{administered}$ (mEq/kg/24 h) | 9.2 ± 3.4 | 6.2 ± 3.4 | 0.0014 |
| Urine output (ml/kg/24 h) | 45 ± 28 | 22 ± 7 | 0.0002 |
| $[Na^+]_{urine}$ (mEq/kg/24 h) | 5.3 ± 3.5 | 1.8 ± 1.2 | 0.000001 |
| $[K^+]_{urine}$ (mEq/kg/24 h) | 1.6 ± 0.8 | 0.9 ± 0.4 | 0.001 |
| $[Cl^-]_{urine}$ (mEq/kg/24 h) | 5.8 ± 3.8 | 2.1 ± 1.2 | 0.000001 |

Results are expressed in mean ± standard deviation.

**Table 4 - Hemoglobin and acid-base variables in the first postoperative 24 h**

| | Low weight | Height weight | p value |
|---|---|---|---|
| Hemoglobin on admission (g%) | 10.9 ± 2.0 | 12.7 ± 2.0 | 0.0021 |
| Hemoglobin at 24 h (g%) | 10.4 ± 1.8 | 11.6 ± 1.7* | 0.0213 |
| pH on admission | 7.34 ± 0.05 | 7.32 ± 0.05 | 0.08 |
| pH at 24 h | 7.39 ± 0.04* | 7.34 ± 0.06 | 0.0022 |
| $PCO_2$ on admission (mm Hg) | 38 ± 5 | 41 ± 7 | 0.09 |
| $PCO_2$ at 24 h (mm Hg) | 37 ± 5 | 41 ± 7 | 0.0147 |
| $PO_2$ on admission (mm Hg) | 108 ± 38 | 89 ± 23 | 0.0431 |
| $PO_2$ at 24 h (mm Hg) | 98 ± 22 | 99 ± 27 | 0.89 |
| $[HCO_3^-]$ on admission (mmol/l) | 20 ± 2 | 20 ± 2 | 0.81 |
| $[HCO_3^-]$ at 24 h (mmol/l) | 22 ± 3* | 22 ± 3* | 0.99 |
| Base excess on admission (mmol/l) | -4 ± 3 | -5 ± 4 | 0.67 |
| Base excess at 24 h (mmol/l) | -3 ± 2* | -4 ± 3* | 0.21 |
| $[Na^+]$ on admission (mmol/l) | 138 ± 4 | 138 ± 5 | 0.91 |
| $[Na^+]$ at 24 h (mmol/l) | 137 ± 3 | 137 ± 4 | 0.74 |
| $[K^+]$ on admission (mmol/l) | 3.7 ± 0.5 | 4.1 ± 0.8 | 0.0211 |
| $[K^+]$ at 24 h (mmol/l) | 3.8 ± 0.5 | 4.2 ± 0.5 | 0.0221 |
| $[Cl^-]$ on admission (mmol/l) | 106 ± 7 | 106 ± 4 | 0.77 |
| $[Cl^-]$ at 24 h (mmol/l) | 105 ± 6 | 104 ± 5 | 0.32 |
| Albumin-corrected anion gap on admission (mmol/l) | 19 ± 6 | 19 ± 4 | 0.63 |
| Albumin-corrected anion gap at 24 h (mmol/l) | 17 ± 5 | 18 ± 6 | 0.47 |
| Arterial lactate on admission (mmol/l) | 2.0± 1.2 | 2.3 ± 1.1 | 0.29 |
| Arterial lactate at 24 h (mmol/l) | 1.5 ± 0.6* | 1.8 ± 0.8* | 0.0470 |

$p < 0.05$ vs. on admission. Results are expressed in mean ± standard deviation.

## DISCUSSION

The main finding in this study was that despite exhibiting very different body weight, postoperative patients received similar hydration plans. Therefore, the lack of consideration of the body weight for that prescription generated a risk of fluid overload in the patients with low body weight.

The morbidity associated with the postoperative fluid administration has been studied by different authors. Walsh et al. prospectively evaluated 71 patients in the first 24 h after colorectal surgery. There was no correlation between fluid and electrolytes prescription and preoperative weight, serum electrolyte levels or ongoing fluid losses. Consequently, a high number of complications, including the fluid overload associated with excessive fluid volume and sodium administration, arose because the available information was not used.[12] Moreover, Arieff reported a series of patients with fatal postoperative pulmonary edema and reviewed its epidemiology in 8,195 major operations.[13] The author found that 7.6% of the patients developed pulmonary edema with a mortality of 11.9%. Extrapolation to the 8.2 million annual major surgeries in the United States yields a projection of 8,000 to 74,000 deaths. Characteristically, the patients' weight was 58 ± 18 kg, a figure comparable to 55 ± 5 Kg found in our low body weight group. This finding probably expresses the fact that body weight is not usually considered for the prescription of fluid therapy and that these patients are at high risk of iatrogenic hypervolemia.

Our study was not designed to investigate the morbidity associated with fluid therapy. Nevertheless, the low weight group was challenged by a large fluid hydration and load of electrolytes as shown by the administration of higher body weight-adjusted volume and amount of electrolytes. Furthermore, the fluid redistribution among body compartments could generate hypervolemia. The fluids administered during the surgery could initially be shifted to interstitial and intracellular compartments but eventually transferred to the intravascular compartment in the postoperative period.[14] Since the renal failure was an exclusion criterion in this study, low weight patients were able to eliminate the intake excess through higher urine output and electrolyte elimination. The higher excretion of salt in these patients could result from expansion of the extracellular compartment, which is a powerful stimulus for the renal excretion of sodium.[15,16]

The use of restrictive or liberal fluid therapy in the intraoperative period remains as a controversial issue. In contrast, after the surgery, ongoing evidence favors fluid restriction. Weight gain and edema were related to worsened outcome after colorectal surgery.[7,17] Tissue edema has correlated with poor wound healing, respiratory alterations, and delayed recovery of intestinal function.[7,18] Compared to the standard fluid therapy (> 3 l), the restrictive management (< 2 l) has resulted in a faster improvement in gastrointestinal activity, fewer complications, and shorter hospital length of stay.[5]

In the low weight group, the lower plasma values of urea, creatinine and albumin on admission and at 24 h. could be explained by differences in the body composition related to malnutrition and female prevalence but also by a dilutional effect produced by fluid overload.

An additional explanation for our results is that low weigh group was more critically ill and the actual needs of fluid resuscitation were higher. This group showed a trend to have more shock and required mechanical ventilation more frequently than the high weight group. APACHE II and SOFA score, however, were similar in both groups. Beyond that the groups might be misbalanced at baseline, another limitation of this study is the small number of patients. Consequently, the study is underpowered to show the effects of the different fluid therapies on the patients' outcome.

## CONCLUSIONS

The lack of adjustment of the fluid therapy to body weight determined that low weight patients received more fluid than high weight patients according to their body weight. This overload could be compensated by increased urine output and electrolyte elimination.


## RESUMEN

**Objetivo:** Comparar las diferencias en el equilibrio de líquidos y electrolitos en los pacientes con bajo y alto peso en el primer día postoperatorio.

**Métodos:** Durante un período de 18 meses, evaluamos prospectivamente 150 pacientes, en las primeras 24 horas después de la cirugía, en una unidad de cuidados intensivos de un hospital escuela afiliado a una universidad. Se compararon pacientes con bajo (≤ 60 kg) y alto peso corporal (≥ 90 Kg) en términos de ingesta y excreción urinariade agua y electrolitos.

**Resultados:** No se observaron diferencias significativas en el volumen (4,334 ± 1,097 vs. 4,644 ± 1,957 ml/24 hs.) y la composición de los líquidos administrados (481 ± 187 vs. 586 ± 288 mEq $[Na +]_{administrado}$/24 hs). El volumen de diuresis en24 horas fue similar (2,474 ± 1,597 vs 2208 ± 678 ml/24 hs.), pero el grupo de bajo peso mostró una mayor eliminación de electrolitos (296 ± 195 vs. 192 ± 117 mEq $[Na +]_{orina}$/ 24 hs., p=0,0246). Cuando los líquidos administrados fueron ajustados al peso corporal, el volumen y cantidad de electrolitos fueron mayores en el grupo de bajo peso (79 ± 21 vs. 47 ± 22 ml/kg/24 h, p <0,0001 y 8,8 ± 3,4 vs. 5,8 ± 3,3 mEq $[Na +]_{administrado}$/kg/24 hs., p = 0,017, respectivamente). Este grupo también mostró mayores producción de orina y eliminación de electrolitos (45 ± 28 vs. 22 ± 7 ml/kg/24 hs., p = 0,0002 y 5,3 ± 3,5 vs. a 1,8 ± 1,2 mEq $[Na^+]_{orina}$/kg/24 hs., p <0,0001, respectivamente).

**Conclusiones:** La falta de ajuste de la terapia con fluidos al peso corporal determinó que los pacientes de bajo peso recibieran más líquidos que los pacientes de alto peso, de acuerdo a su peso corporal. Esta sobrecarga de líquidos pudo ser compensada por el aumento de la diuresis y la eliminación de electrolitos.


**Descriptores:** Tratamiento con líquidos; Electrolitos; El período postoperatorio; Peso corporal


## RESUMO

**Objetivo:** Comparar as diferenças no equilíbrio hídrico e eletrolítico em pacientes com baixo e alto peso corpóreo no primeiro dia pós-operatório.

**Métodos:** Em um período de 18 meses avaliamos prospectivamente 150 pacientes durante as primeiras 24 horas após cirurgia, na unidade de terapia intensiva de um hospital universitário. Pacientes com baixo (≤60 kg) e alto peso corpóreo (≥90 kg) foram comparados em termos de fornecimento e eliminação de fluidos.

**Resultados:** Não foram observadas diferenças significantes em termos de volume (4,334 ± 1,097 em versus 4,644 ± 1,957 mL/24 horas) e composição dos fluidos administrados (481 ± 187 versus 586 ± 288 mEq $[Na^+]_{administrados}$ em 24 horas). O débito urinário em 24 horas foi similar (2,474 ± 1,597 versus 2,208 ± 678 mL/24 horas), porém o grupo com baixo peso teve uma maior eliminação de eletrólitos (296 ± 195 versus 192 ± 117 mEq $[Na^+]_{urina}$/24 horas, p=0.0246). Quando os fluidos administrados foram ajustados ao peso corpóreo, o volume e quantidade de eletrólitos dos fluidos administrados foram maiores no grupo com baixo peso (79 ± 21 versus 47 ± 22 mL/kg/24 horas, p<0.0001 e 8,8 ± 3,4 versus 5,8 ± 3,3 mEq $[Na^+]_{administrado}$/kg/24 horas, p=0,017, respectivamente). Este grupo também demonstrou maior débito urinário e eliminação de eletrólitos (45 ± 28 versus 22 ± 7 mL/kg/24 horas; p=0,0002 e 5.3 ± 3.5 vs. 1.8 ± 1.2 mEq $[Na^+]_{urina}$/kg/24 horas; p<0,0001, respectivamente).

**Conclusões:** A falta de ajuste da terapia hídrica ao peso corpóreo determinou que os pacientes com peso baixo recebessem mais líquidos do que os pacientes com peso elevado, de acordo com o peso corpóreo. A sobrecarga hídrica poderia ser compensada pelo aumento do débito urinário e eliminação de eletrólitos.

**Descritores:** Hidratação; Eletrólitos; Período pós-operatório; Peso corporal

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