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Estimation of fluid status changes in critically ill patients: Fluid balance chart or electronic bed weight?☆

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Abstract

Purpose: Monitoring of fluid balance (FB) can be achieved by subtracting recorded fluid output from input or by measuring changes in body weight (BW). The latter approach is difficult in the critically ill. Recently, hospital beds have become available with the ability to directly weigh patients in the intensive care unit (ICU) patients directly. We sought to compare FB estimates obtained by these 2 methods in a cohort of critically ill patients.

Materials and Methods: Between November 2010 and May 2011, all patients admitted in our ICU for more than 2 consecutive days and nursed on a Hill-Rom (Batesville, Ind) Total Care bed were weighed daily at midnight hours. Fluids charting was done by electronic spreadsheet with automated 24 hours calculation. Differences in BW and FB between 2 consecutive days were compared using correlation and Bland-Altman analysis. Corrections for unmeasured fluids losses were performed using a predetermined formula based on peak temperature and intubation status.

Results: We obtained complete data in 160 (31%) of 504 admissions exceeding 2 days (153 patients) resulting in 435 data points. The change in BW over 24 hours and FB for the same period was only weakly correlated before ($r = 0.34$; $P < .001$; Fig. 1) or after correction for insensible fluid losses ($r = 0.34$; $P < .001$). On Bland-Altman plot, the mean bias was small (0.07 kg), but the 95% limits of agreement, very large (−5.8 and 6.0 kg). The lack of agreement increased with the magnitude of the changes.

Conclusion: Obtaining daily weights in ICU patients proved difficult. Compliance was poor. The correlation between changes in BWs and FB was weak. Further studies are required to establish if accurate and reproducible daily weighing of ICU patients is feasible.

1. Background and rationale

Fluid management is important in critically ill patients. On one hand, aggressive initial fluid therapy has been shown to decrease mortality in sepsis [1]. On the other hand, numerous studies have shown an association between positive fluid balance (FB) and increased mortality [2-7].

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In the intensive care unit (ICU), the recording of inputs and outputs allows the calculation of a daily FB. However, entered data can be incomplete or inaccurate; some fluids losses such as perspiration, respiration, or diarrhea are not taken into account or measured [8], and if the data are not entered in a computerized system, calculation errors might occur. These multiple error sources tend to add up, and the cumulative calculated FB tends to be less and less accurate over a patient ICU stay [9-11].

Because, over a short period, changes in body weight (BW) are almost only associated with change in body fluids, measurement of BW may be a more accurate way of estimating fluid status. This approach might be suboptimal in patients with extended ICU stay, where muscle and fat loss as well as bone demineralization are likely to play a role in changes in BW [12]. However, for most ICU patients and at least probably for the first week of ICU stay, changes in BW are likely to be a reliable estimate of FB.

Unfortunately, weighing the critically ill patients is technically difficult, as sedation, invasive monitoring, and equipment make use of standard scales impossible. For example, among 5 key studies [13-17] involving renal replacement therapies and setting ultra filtrate rate based on weight on admission, only 1 indicated that an actual measurement was done, and this method was not described [16]. Several devices have been designed and marketed, but they are either inaccurate or very cumbersome [18]. Bioimpedance measurement and bioimpedance vector analyses techniques are promising [19-22], but their use in clinical practice needs to be established. Recently, beds with built-in patient weighing scales have been made available. According to the manufacturer [23], the accuracy of the scale is ±1% of the patient's weight, and the repeatability is ±0.3% (<75 kg) and 0.1% (>75 kg). However, their use in the ICU has not been well described or validated.

Accordingly, we sought (1) to evaluate the feasibility and ease of use these beds in our ICU and (2) to test the correlation between the FB estimated by the traditional charting method and by evaluation of BW using the study device.

2. Materials and methods

We designed an observational study of all consecutive patients admitted in ICU for more than 48 hours and occupying beds with weighing capabilities. At the time of the study, these beds represented 14 of 20 of ICU beds. Patients were excluded if their weight was above 181.4 kg (400 lb) or if the bed was not tared (zeroed with linen, pillows in place) before admission. We aimed to obtain data from a convenience sample of more than 100 patients.

The study protocol was approved by the human research ethics committee of our hospital, and the need for informed consent was waived.

2.1. Study beds

We used Hill-Rom (Batesville, Ind) Avant guard 1600 and Total Care bed systems. Both these beds offer easy bed taring and weighing capacities. Before the beginning of the study, basic training on how to operate and tare the bed was provided to the nursing staff. Emphasis was placed on the importance of taring the bed before patient's admission and to temporarily remove any extra weight from the bed.

2.2. Weighing procedure

While the ICU bay was prepared before an admission, the bed was tared (calibrated). This tare procedure included a standard list of beddings, pillows, and sheets. The patients were then weighed daily at midnight to coincide with the 24-hour FB calculation. Before pressing the "weigh" button, the nurse was required to remove any extra weight not included in the tare items list. These included urinary bags, drains, or disinfectant bottles. Items attached to the bedside poles were not to be touched. The head of the bed had to be tilted to lower than 30°, then the weigh button could be pressed. Altogether, this process should take less than 5 minutes. The results were reported in a dedicated study data collection tool describing the procedure and its important steps, kept at each bedside.

2.3. Fluid balance calculation

A structured query language-based electronic FB chart (SLIC version 5.38; Incarta IT, Melbourne, Australia) was used to calculate the FB. This software was accessible through a monitor interface available in each ICU bay. It requires an hourly entry for inputs (maintenance fluids, fluid boluses, blood products, intravenous medications, nutrition...) and outputs (urinary output, drains contents, estimation of feces volume...). The FB was calculated in real time and locked at midnight for the previous day.

2.4. Insensible fluid losses evaluation

Each study day, to allow for evaluation of insensible fluid losses (IFL), we collected intubation status and maximal body temperature. We calculated the volume of IFL according to a predetermined formula [8]: IFL (milliliters) = 800 + 20% × 800 × (maximum temperature − 37). This value was divided by 2 if the patient was intubated.

2.5. Statistical analysis

We compared changes in BW between 2 consecutive days and the corresponding day FB. Descriptive statistics are presented as mean and SD or median and interquartile range (IQR) as appropriate; ordinal data are presented with number and percentage. The FB and BW data were normally