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## Fluid, Fluid Everywhere, and All the Organs Did Not Shrink; Fluid, Fluid Everywhere, Administered Without a Think\*

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Much, if not all, of critical care is a J-(or U-) shaped curve. On the left side of the  $x$ -axis, the inadequate provision of a particular therapy is associated with an increase in complications, demonstrated on the  $y$ -axis. On the right side of the  $x$ -axis, an overabundance of the same therapy will also increase complications and worsen outcome. The main objective of training in Critical Care Medicine is to, therefore, provide the clinician with the necessary skills to treat patients at the bottom of the curve, where the complication rate is at its lowest. In essence, our goal in caring for the critically ill should be to attain Goldilocks status. Outcomes are therefore optimized by “just right” therapy, which can change based on timing, severity, and an individual patient’s response, followed in a short-loop feedback fashion. Goldilocks would be a fantastic intensivist.

It is with that analogy in mind that we can think of fluid resuscitation. Spanning several eras gone by, the benefits of

fluids have been demonstrated in patients with: 1) cholera and hypovolemia, 2) extracellular (“third space”) fluid loss, 3) underresuscitated cryptic shock, and 4) supranormal resuscitation targets (1–4). Decades ago, a greater concern was that critically ill patients were too frequently on the left side of the  $x$ -axis, with commensurate complications related to underresuscitation. So a prevailing dogma stated that critically ill and injured patients should receive large volumes of fluid, with little consideration of any objective, individualized data. Not surprisingly, this will violate the Goldilocks principle, and a significant amount of outcomes data now demonstrate the dangers of overresuscitation and positive fluid balance (5, 6). We now seem to be operating on the right side of the  $x$ -axis all too frequently with respect to fluid administration.

It is under this backdrop that Silversides et al (7), in their article published in this issue of *Critical Care Medicine*, conducted a multicenter cohort study on mechanically ventilated patients to describe fluid administration practice and to assess the impact of fluid balance and deresuscitation measures (i.e., fluid removal with furosemide or renal replacement therapy) on clinical outcomes. A convenience sample of 400 patients from 10 ICUs in Canada and the United Kingdom comprised the cohort. Multiple regression models and sensitivity analyses were employed to adjust for potential confounding related to illness severity, comorbid conditions, and fluid balance.

Some of the descriptive data have been described before and are expected: higher fluid balance was observed in nonsurvivors. Yet some are unique and thought-provoking, including that over 60% of fluid input during the first 3 days was from medications and maintenance IV fluids, whereas only 24.4% of volume was accounted for by fluid boluses. There was also marked variability in practice regarding both dose and sources of fluid between sites and with the use of deresuscitation measures. There was a mortality association with greater fluid

\*See also p. 1600.

**Key Words:** deresuscitation; fluids; outcomes

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The title of this editorial was adapted from passages from “The Rime of the Ancient Mariner” by Samuel Taylor Coleridge.

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balance on each day during the first week, with the strongest association at day 3. Multivariate logistic regression modeling demonstrated day 3 fluid balance to be an independent predictor of mortality, and these results were robust across multiple analyses. Day 3 fluid balance was also associated with worse organ dysfunction.

In patients with a negative fluid balance on day 3, deresuscitation was associated with a lower mortality when compared with positive fluid balance. Interestingly, the highest gross mortality was observed in patients that had received deresuscitation measures but remained with a positive fluid balance on day 3. This association was no longer observed after multivariable analysis, suggesting that active deresuscitation attempts were not responsible for the observed higher mortality in the positive fluid balance group.

The authors did not intend to conduct the definitive study in this area and acknowledge several limitations, including a lack of pre-ICU fluid administration data, a relatively small number of patients, and the study design. There are several strengths, including stability of the findings with multiple analyses, strong biological plausibility, and a demonstrated dose-response. These facts suggest causation, as opposed to mere association. However, the greatest strength of the study by Silversides et al (7) is the question and the topic itself, as fluid administration is almost universal in the ICU.

So what is the takeaway for the practicing clinician after reading this work (7)? When put into context with the significant data regarding fluid overload and outcome, several thoughts come to mind. First, a patient should be given fluids: 1) if they are hypotensive and/or hypoperfused (they actually need an intervention); 2) if preload responsiveness exists (they will actually respond to the intervention in a positive way); and 3) with a therapeutic endpoint in mind (guidance regarding cessation of the intervention). Second, fluids should be administered as a rapid bolus, not slowly over time, and the routine prescription of “maintenance” fluids should be strongly discouraged for the great majority of critically ill patients. This practice pattern typically involves a fluid composition and rate that are completely arbitrary and often prescribed by the most inexperienced team member, with no therapeutic target in mind. Furthermore, the vast majority of fluids do not remain intravascular, especially when trickled in at a slow rate, and the effects of fluids are quite transient (8). Maintenance fluids create fluid creep and unnecessary positive fluid balance, a predictor of worse outcome. This work by Silversides et al (7) suggests that early fluid administration in the ICU not only contributes to worse outcome but has significant room for practice improvement with respect to dose, duration, and

deescalation of therapy (6). Finally, in the setting of positive fluid balance, late conservative fluid management can improve outcome (9–11). The current study by Silversides et al (7) goes a step further and suggests that active deresuscitation to remove fluid should be strongly considered.

This investigation is important because the authors have targeted a ubiquitous intervention in the ICU and have provided ample rationale for the conduct of a prospective, interventional study. Until we await further data on this topic, the current work (7) combined with the existing body of literature demonstrates benefit to avoiding iatrogenic volume overload, and promoting euvolemia seems like a low-risk intervention that can be employed readily at the bedside.

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