



Merits and limitations of fluid balance

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Nobody will argue with the observation that a positive fluid balance is associated with increased mortality rates (1-3). Indeed, this finding is not surprising, because patients who are more severely ill are more likely to develop edema whether or not they have renal failure. Therefore, studies investigating the impact of fluid balance on outcomes must use multivariable or propensity-matched analyses that include many variables in order to determine whether fluid balance is independently associated with outcome. This has been done in several recent studies. In a study conducted in our Department of Intensive Care in Brussels, fluid balance was more positive in non-surviving than in surviving patients with sepsis, and these factors remained related even after adjustment for many variables (2). The monocentric nature of the study may be seen as a weakness, but it is also a strength because it means that variability in patient management was limited. Larger observational studies conducted in Europe (3) and worldwide (1) have shown similar results. These two studies included many variables, enabling quite extensive multivariable analyses to be conducted. In the SOAP study (3), a positive fluid balance had an impressively high prognostic value, just below that of the SAPS II score. In the recent analysis of the ICON database, the effects of a positive fluid balance, again significantly associated with outcome, were particularly important after the first 24 hours (1).

Balakumar *et al.* (4) recently published an interesting review of a large database of more than 18,000 patients treated in the eight ICUs of the University of Pittsburgh Medical Center. Their analysis provided several interesting results. First, a

positive fluid balance was independently associated with worse short- and long-term outcomes. Although the association with short-term outcomes is now quite well established, the extension of these observations over time is interesting. Second, a more negative fluid balance was associated with better (by about 20%) short-term outcomes, but worse (also by about 20%) long-term outcomes. This reminds us of the US Fluid and Catheter Treatment Trial (FACTT) on fluid management in patients with acute respiratory distress syndrome (ARDS) (5). In that prospective, randomized controlled trial, patients who received a conservative fluid management strategy had a shorter duration of mechanical ventilation, a not too surprising finding. More interestingly, long-term observation of a subgroup of the enrolled patients suggested that those ARDS patients randomized to the conservative management group had more severe neurological impairment (6). This observation suggests that a more restrictive fluid strategy may have improved lung function but impaired oxygen delivery and thus cerebral blood flow in these patients. Third, the increase in mortality in patients with a positive fluid balance was attenuated in patients treated with renal replacement therapy (RRT), suggesting that RRT can improve outcome through a better control of the fluid status.

All these studies, however, consider global patient populations, but each patient has individual fluid requirements that fluctuate over time. Using the SOSD (Salvage, Optimization, Stabilization, De-escalation) construct (7), one can consider an initial Salvage phase wherein the primary aim is to sustain life before a monitoring system can be placed. The Salvage phase should be followed by the optimization

phase as soon as possible, and it may take just a few minutes to already have an echocardiographic evaluation in position. If the patient does not respond quickly to fluids, some form of invasive monitoring should be considered to allow a correct fluid challenge technique to be performed (8). Measurements of cardiac filling pressures are helpful and the central venous pressure (CVP) is easily obtained in any patient. The principle of the fluid challenge technique is that a positive response will be manifest by a large increase in cardiac output associated with a limited increase in CVP, whereas poor tolerance to fluids will result in a large increase in CVP for a limited improvement in tissue perfusion. Signs of fluid responsiveness can be identified in some patients, although these are usually restricted to patients who are deeply sedated on mechanical ventilation. Passive leg raising can be accomplished in spontaneously breathing patients, but the technique is less easy than one may think, because the patient's response is based on a transient increase in stroke volume. Importantly, all these techniques should be used not so much to evaluate when more fluid is needed, but rather when fluids should be avoided. Once the patient has reached the stabilization phase, the de-escalation phase can be considered, in which a negative fluid balance is expected as edema is eliminated. This phase is usually spontaneous, but if not, diuretic administration and even RRT can be used.

The Surviving Sepsis Campaign guidelines indicate that initial fluid resuscitation should consist of 30 mL/kg over 3 hours (9). This recommendation over such a long period of time is not very helpful, but the group felt there are not sufficient data available to make more specific recommendations. However, these guidelines recommend using a fluid challenge technique to evaluate the patient's response. The more recent guidelines for management of sepsis in children (10) recommend starting with 20 mL/kg, and evaluating the patient's response in terms of arterial pressure (MAP), heart rate and signs of tissue perfusion. If the child does not respond quickly to fluids, the guidelines recommend considering some form of invasive monitoring, underlining that measurements of cardiac filling pressures can be particularly useful. They indicated that little change in CVP in response to a fluid bolus suggests that more fluid is indicated, whereas increase in CVP associated with a reduction in the MAP-CVP gradient suggests that fluid administration should be stopped.

In summary, large observational databases are interesting to generate data, but cannot provide the full story. The SOSD phases vary from one individual to another and fluid administration must be individualized, taking individual time frames and needs into consideration.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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