Perioperative Fluid Management

Turning Art to Science

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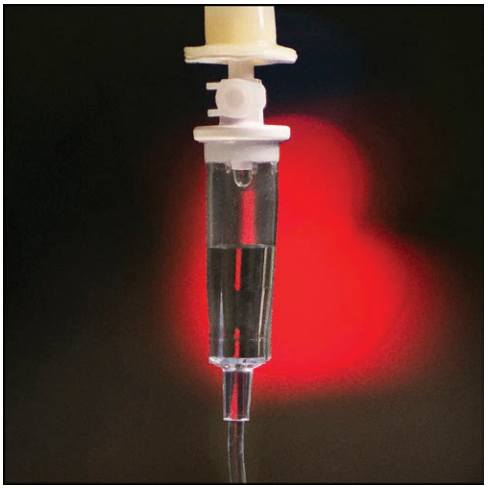
Appropriate fluid management is a cornerstone of anesthetic practice.[1] Unfortunately, there is disagreement as to how to translate that goal into practice. Anesthesiologists know that too much fluid may lead to complications from side effects, including tissue edema, poor cardiac function, or pulmonary compromise. Too little fluid may also be harmful, potentially leading to inadequate tissue perfusion, impaired wound healing, and higher risk of deep venous thrombosis. Textbooks provide guidelines for calculating fluid management, based on patient and surgical factors, but they are not strongly evidence-based, and interpretation and implementation vary widely. Although there are many randomized trials of fluid management and outcome, most compare fixed volumes of a colloid, usually a hydroxyethyl starch solution, and a crystalloid, usually a balanced salt solution, without any measure of physiologic comparability.[2] Thus, it is unclear whether the outcomes of the trials result from the type of solution, the relative volume of solution, or both. The study by Kabon *et al.*[3] in this issue of Anesthesiology represents a step in the right direction: in relatively healthy patients undergoing major abdominal surgery, the effects of crystalloid *versus* tetrastarch hydroxyethyl starch colloid fluid administration on outcome were compared using goal-directed, that is physiologically comparable, rather than fixed-dose fluid administration. In contrast to a number of previous studies comparing fixed doses of colloid and crystalloid, there were no differences in major or minor composite outcomes, mortality, or hospital readmission, suggesting that effective volume may be more important than type of fluid.



"[E]ffective [fluid] volume may be more important than type of fluid."

The investigation by Kabon *et al.*[3] was a parallel-arm, double-blind, multicenter, randomized trial in 1,057 patients undergoing moderate- to high-risk open and laparoscopic-assisted (n = 10) abdominal surgery under general anesthesia to test the hypothesis that goal-directed colloid administration reduces 30-day major complications compared with goal-directed crystalloid administration. Both groups received crystalloid solution at a fixed rate: 5 to 7 ml/kg ideal body weight as a bolus during induction, followed by 3 to 5 ml · kg^{-1} · h^{-1} throughout surgery. All patients had a transesophageal echocardiography probe placed after induction for the purpose of Doppler-guided intraoperative volume management. Boluses of 250 ml of study solution, either hydroxyethyl starch (colloid) or lactated Ringer's (crystalloid) according to randomization, were administered based on established stroke volume and corrected aortic flow time criteria.[4] An observer blinded to group assignment evaluated complications during hospitalization and called patients 30 days after surgery to assess postdischarge complications, readmission, and vital status. Patients in the colloid group received a mean of four (range two to six) boluses, whereas those in the crystalloid group received a mean of five (range three to eight). Total fluids given were 3.2 l of crystalloid in the crystalloid group and 1.8 l crystalloid and 1 l of colloid in the colloid group. There was no difference in major complications, minor complications, 30-day mortality, or 30-day readmission rate. There was no evidence of excess renal toxicity in the colloid group.

Despite their limitations, previous studies comparing hydroxyethyl starch colloid *versus* crystalloid based on fixed dosing[5,6] contributed to a gradual change in practice favoring reduced fluid administration during abdominal surgery, regardless of whether colloid was given, and without routine physiologic measurement of the adequacy of intravascular volume. This restrictive approach was incorporated into many Enhanced Recovery After Surgery protocols as part of a bundle intended to reduce postoperative complications.[7]

The current study and another recent study[8] have begun the process of sorting out the relative contributions of fluid type and fluid volume. Myles *et al.*[8] examined fluid

Image: J. P. Rathmell.

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administration independent of fluid type in a pragmatic, international, randomized trial comparing restrictive (~3.7 l) *versus* liberal (~6.1 l) administration of crystalloid in patients undergoing major abdominal surgery. There was no difference in disability-free survival between groups, but the restrictive group had a significantly increased risk of acute kidney injury (8.6% *vs.* 5.0%, $P < 0.001$). The current study investigated the effect of fluid type in the setting of physiologic comparability of dosing. Both should contribute to a reassessment of fluid management in major abdominal surgery. Given the lack of evidence of benefit, the higher acquisition cost, and the potential serious side effects of hydroxyethyl starch colloid administration (renal toxicity[9] and pruritis[10]), the current study does provide strong support for the use of crystalloid over colloid for maintenance fluid management in patients undergoing major abdominal surgery.

Although, overall, this was a well-designed study, several limitations reduce its generalizability. Although multicenter, the study included only three centers, one of which enrolled only 52 patients. Enrollment in the study took 10 yr, and practice clearly changed over the course of those 10 yr, so the results must be interpreted with caution. During the course of the study, evidence emerged that hydroxyethyl starch colloids are associated with renal failure in critically ill patients[9] and cause severe and prolonged pruritis in up to 20% of patients.[10] Both of these findings decreased the use of hydroxyethyl starch colloids, making albumin a more commonly used colloid at many centers. These side effects are not seen with albumin, so the results cannot be generalized to all colloids.

The study was performed in relatively healthy patients and thus the results cannot be extrapolated to patients with more severe comorbidities, who may be at higher risk for renal toxicity. The sample size is not large enough to definitively establish the safety of hydroxyethyl starch colloid, particularly given that most patients were not at known high risk for renal toxicity and had no evidence of renal insufficiency at baseline. Concerns about the safety of hydroxyethyl starch colloid in patients undergoing major abdominal surgery may be moot, because the lack of evidence of benefit in the context of higher acquisition cost and potential toxicity suggest that crystalloid is the better choice for these patients in any case.

In this study, hydroxyethyl starch colloid was used to replace maintenance and insensible fluid losses, rather than blood loss, which was almost uniformly small. There is some support for the use of crystalloid to replace fluid losses and colloid to replace blood loss,[1] but that could not be evaluated in this study, given that blood loss was almost uniformly minor.

The most intriguing question raised (but not answered) by the current study is whether fluid administration in patients undergoing major abdominal surgery should be routinely managed with a goal-directed method such as transesophageal echocardiography or pulse-volume variation. Such monitoring would add expense and complexity to the management of these patients, but could add value if its use decreases the rate of postoperative complications. The study by Myles *et al.*[8] suggests that fixed-dose regimens may be effective, although further research is required to establish evidence-based dosing. Such an approach, moreover, does not account for differences in baseline condition and ongoing fluid losses between patients, so it seems likely that an individualized approach may be more effective. The next challenge is to establish evidence-based protocols for goal-directed fluid therapy so that perioperative fluid management can become more science than art.

Competing Interests

The authors are not supported by, nor maintain any financial interest in, any commercial activity that may be associated with the topic of this article.

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ANESTHESIOLOGY REFLECTIONS FROM THE WOOD LIBRARY-MUSEUM

From Dr. Vernon Harcourt, Chloroform Man, to *Dr. Quinn, Medicine Woman*: An Anesthetic Anachronism?

A television series starring Jane Seymour, *Dr. Quinn, Medicine Woman* portrayed the adventures of a physician as supposedly set from 1867 to 1873 in Colorado Springs, Colorado. Manufactured by J. J. Griffin of London, this Portable Vernon Harcourt Chloroform Inhaler (*right*) was borrowed from its previous owner as a prop on the *Dr. Quinn* set. Because inventor A. G. Vernon Harcourt did not reveal his eponymous inhaler (depicted, *left*) to the Royal Society until 1902, the appearance of the device on *Dr. Quinn* was at least a 30-yr anachronism. Fortunately, the prop was sold to the Wood Library-Museum well before the entire set of *Dr. Quinn* in California's Agoura Hills was burned to the ground in the 2018 Woolsey Wildfire. (Copyright © the American Society of Anesthesiologists' Wood Library-Museum of Anesthesiology.)

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