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Fluid administration: How much is enough?

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«Water, water, every where.
Nor any drop to drink»
Samuel Taylor Coleridge, The rime of the Ancient Mariner, 1797

Perioperative fluid therapy remains controversial! Should we give more fluids or less fluids? Which fluid is indicated and when? Can we influence outcome or is that already predetermined by the patient's condition? Many studies address these fluid issues from every angle. Some have supported and others have refuted all these points. What should the anesthesiologist do?

Critical review of clinical trials reveals that current standard fluid therapy is hardly evidence based and has been challenged for years[1]. Indeed, some 90 years ago, Cannon pointed out that the administration of fluids before operative control of an injury was ineffective[2]. Bickell emphasized the benefit of surgical correction before resuscitation; fluids could blow out a soft clot. But during both the Korean and Vietnam campaigns, in the United States military large fluid volume resuscitation was advised to maintain renal perfusion. Thus the da Nang lung was born. Rational thinking for fluid therapy lost ground in favor of the kidney.

Tradition has taught us that there are three fluid spaces. The first is readily recognizable as the intravascular space. The second, generally considered to be interstitial and extravascular spaces where fluid accumulates either normally or in response to injury or edema formation, is not as well defined or quantified. Fluid shift between these 2 spaces is ongoing and can obscure hypovolemia or overload. For example, vascular beds can undergo dramatic capacitance changes secondary to anesthetic drugs, infusion of hyperosmolar substances and pathologic states and thus draw fluid from the interstitium. Or fluid may leak to interstitial spaces in response to failure of the cardiovascular pump system. But where is the third space, which is said to be related to the surgical experience and thus requires special attention?

Almost 50 years ago, 2 groups of patients were studied in an attempt to more closely understand the acute changes that determine the perioperative management of fluids and electrolytes[4]. The control group consisted of 5 patients undergoing minor surgery with general anesthesia and the second group (13 patients) had elective major surgical procedures (cholecystectomy, gastrectomy and colectomy). Plasma volume, red blood cell mass and extracellular fluid volumes were measured in all patients on 2 occasions during the operative period by using I *131* tagged serum albumin, chromate *51* red blood cells and sulphur *35* tagged sodium sulphate. Based on the finding of a decrease in functional extracellular fluid in group 2, the authors concluded that there was internal redistribution of fluid associated with surgery (that is, the third space was discovered!) which should be replaced by fluid administration. These findings were «confirmed» in an exsanguinated dog model which did better with immediate fluid rather than blood replacement[5]. Arguing against this «logic» Moore, an anesthesiologist, postulated that a metabolic response to surgical stress caused sodium and water retention and perioperative fluid restriction was indicated[6]. (The debate even prompted an editorial by the two combatants which urged moderation[7].

The excessive fluid doctrine appears to have won. Protocols were developed that calculated deficits based on degree of trauma, insensible losses and a host of other «variable» fluid decreases, all of which were to be replaced with crystalloids. Every house officer can repeat the 4:2:1 «rule», found in all major textbooks, where it appears with gospel-like intonation, although without reference (0-10 kg requires 4 mL/kg, 11-20 kg 2 mL/kg and > 21 kg is 1 mL/kg. However, in one authority one can read that the «rule» «segments the curvilinear relationship between body weight and metabolic rate into 3 linear parts»[8]. Now what exactly that means is difficult to understand. If water requirements are proportional to metabolic rate and if basal metabolic rate is related to body surface area then surely formulae should take into account neurologic, endocrine, cardiovascular status not to mention maintenance and anesthetic drug administration. What currently guides us is far too simplistic!

There is also the concept of preoperative dehydration. Are patients so dehydrated when they arrive at the hospital at 7AM after having fasted for 8 hours that they require some 1,500-2,000 mL fluid (that is 6-8 cups of coffee) within the first 1-2 hours of surgery and perhaps a total of 3-5 liters over 4-5 hours, especially if there is a 2 unit blood loss ? A poll of anesthetic house staff in New York indicated that while many insert intravenous cannulae and give lots of fluids, by 10AM their own average intake of coffee/tea/juice is 240 ± 240 mL. None of these doctors were in metabolic coma. Why then should our patients require so much fluid? Moreover, given that most of our agents today are very short acting. Most patients are able to drink within an hour of the end of surgery.

Several studies suggest that fluid resuscitation may be over generous and even contribute to complications such as pulmonary edema, myocardial dysfunction, bacterial translocation and development of sepsis, wound infection and multiorgan failure Patients who developed postoperative blindness after lumbar surgery also had a very large positive fluid balance[9]. Could restricting intravenous fluids then be beneficial? Comparison of the standard (> 3 L, normal saline) versus restricted (< 2 L, 0.45 normal saline) protocols for postoperative fluids after hemicolectomy indicated significantly more complications in the standard group. Median solid and liquid phase gastric emptying times on the fourth postoperative day were significantly longer in the standard group than in the restricted group (p = 0.028 and p = 0.001), median time to passage of stool 3.5 days later (6.6 *vs* 4 days, p = 0.001), and median postoperative hospital stay (9 *vs* 6 days p = 0.001)[10].

Which type of fluid is better? Crystalloids or colloids? Or does it matter? During short, ambulatory cases with low surgical risk it may be of no importance. Intravenous crystalloids remain in the intravascular space for very short periods, redistributing quickly to soft and damaged tissue and dependent areas (gut, lungs and larynx). Edema in the gut wall increases the inflammatory response and retards forward movement. A more serious complication is abdominal compartment syndrome causing respiratory and renal dysfunction and increased epidural bleeding during spine surgery[11]. Excessive crystalloids also cause coagulation abnormalities (dilutional or hypercoagulation) and delay wound healing through increased cutaneous edema[12]. Moreover, patients go home from a short hospital stay after having had a part removed 10-20 lbs heavier! This extra «weight» may take several days or even weeks to lose.

Colloidal expanders include albumin or hetastarch (Hespan® or Hextend®). Albumin, 55 or 25% supplied in 100 mL aliquots is derived from pooled human venous plasma which is heated to 60 degrees for 10 hours to inactivate hepatitis viruses. It contains no isoagglutinins and thus the risk of adverse reactions is very low. Hetastarch in 0.9% sodium chloride is a synthetic polymer derived from a waxy starch composed of amylopectin. It is supplied in 500 mL bags. Both albumin and hetastarch expand plasma volume by the amount infused. Preparation charges make albumin significantly more expensive. We have been advised that hetastarch should be avoided because it causes bleeding, although it stays in the intravascular space some 20 times longer than crystalloid. Indeed, hetastarch may induce a hypocoagulable state although volumes in excess of 5,000 mL may be required before coagulation abnormalities are seen[13]. But would a tendency to decreased coagulation be so awful, given that a major complication of surgery and hospitalization is deep venous thrombosis and many of our protocols are aimed at avoiding this problem and its consequences? Crystalloids have been shown to produce a hypercoagulable state at 20-40% dilution whereas lower molecular weight hydroxyethyl starches and colloids in suspended salt solutions exert minimal coagulation derangements[14]. The tetrastarches, hydroxyethyl starch 130/0.4, recently approved in the United States, have been shown to represent a substantial advance in colloid therapy, offering good volume replacement with a low risk of side effects[15]. They have also been proven superior and less expensive than albumin for volume replacement in children undergoing cardiac surgery[16]. Particularly convincing of the superiority of colloids for perioperative fluid replacement is the ability of hydroxyethyl starch to improve tissue oxygen tension (pti02) significantly more than crystalloids[17], indicating improved microperfusion and less endothelial swelling.

The message, aptly relayed in a recent article, is that we need to reevaluate and most probably restrict perioperative fluid management[18]. Preoperative volume loading is not necessary in most cases. The classic «third space» does not exist. Crystalloid overload is bad. Routine replacement of insensible losses is to be eschewed. Demand related regimens should be followed to improve patient outcome. Perioperative fluid shifting must be minimized by restricting excessive administration of fluids that are quickly redistributed outside the vascular space. Fluid balance should be maintained (input to urine output). Inappropriate intravenous fluid therapy is a significant cause of patient morbidity and mortality and in most, uncomplicated cases, a restrictive fluid approach appears preferable[19]. But given the enormous variability of the patients, their conditions, and the surgical procedures, we are still lacking the optimal perioperative parameters to assess what represents appropriate fluid replacement. The intravascular space is not static. The esophageal Doppler, supplying continuous real time objective data, may well emerge as the monitor of preload conditions and help us manage cardiac contractility and the effect of afterload impedance on left ventricular performance Our time honored protocols could soon blow in the wind.

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