SCIENCE AND TECHNOLOGY

Perioperative Fluid Therapy

Optimal Fluid For High-Risk Surgical Patients, A Change In Thinking

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As I researched the topic of intra-operative fluid management for a resident lecture, I (as frequently occurs) was surprised to find out how much I did not know about the topic. The expansion of enhanced recovery programs throughout the world has forced us to rethink many aspects of our care including fluid administration whether calling it restrictive fluid therapy or more appropriately, goal-directed fluid therapy.

First, we must think of fluids as medications and not just carriers since their administration can alter the composition of electrolytes within the body as well as organ perfusion.

To put this into perspective, the administration of a liter of 0.9% normal saline which can occur over minutes with a large bore IV or central line increases the patient's weight by about 2.2 pounds (1/3 the daily requirement for water) and provides three times the daily requirement of salt (9 grams). This is the salt equivalent of a few dozen bags of potato chips.

Pre-operative fluid deficit is greatly overestimated based on the formulas we used when we trained. The NPO requirements have been relaxed allowing and even encouraging clear liquids up to two hours before surgery. Furthermore, the placement of drains such as nasogastric tubes and foley catheters is now discouraged. Lastly, many procedures are performed using minimally invasive techniques reducing the blood and evaporative losses. Therefore, if we give fluids as freely as when we trained, volume overload can be expected.

Recent studies show that fluid administration is not given much thought when in the operating room. A study from 2017 titled *Analysis of Variability in Intraoperative Fluid Administration for Colorectal Surgery: An Argument for Goal-Directed Fluid Therapy* found that there was significant variability in the type and amount of fluid administered as well as the fluid administration rate during colorectal surgery. The mean for total crystalloid administration was 2578 ml with a standard deviation (SD) that was approximately 50% of the mean value. A combination of both normal saline and lactated Ringer's solution was used in almost all cases without a clear rationale for fluid choice. Fluid administered to patients was disproportional to measured intraoperative fluid losses (estimated blood loss and urine output) by a factor of 10. The average rate of fluid given was 1050 mL/h with an SD of nearly the same amount (951 mL). And there was a variability of over 67% in total crystalloid administered based on both ideal body weight and total body weight.[1] Another study from 2015 titled *Variability in Practice and Factors Predictive of Total Crystalloid Administration during Abdominal Surgery: Retrospective Two-Centre Analysis* found a wide variability in crystalloid administration both within and between individual anesthesia providers, which might contribute to variability in surgical outcomes.[2]

What is goal-directed fluid therapy? The goal is to optimize stroke volume. It requires a pre, intra and post-operative plan. At any point, the plan can fail if not followed. Low urine output protocol: tolerate it. Studies show that intra-operative urinary output does not correlate with post-operative acute renal injury. What the patients require is "oxygen delivery", therefore they need "flow" not necessarily pressure. Without a device to measure stroke volume/flow intra-operatively, the best determinant of a fluid deficit is a hemodynamic response to a fluid bolus. The administration Of 250 ml of crystalloid or colloid is common. There are two parts to the fluid therapy: maintenance therapy and volume therapy. Maintenance therapy replaces insensible losses and urine output which should be 1-1.5 ml/kg/hr for most procedures with higher rates for those involving the larger incisions. Volume therapy treats hemodynamic changes with fluid boluses. Vasopressors are added to increase blood pressure if you feel that the fluids are optimized.

"...using starches, dextrans, albumin, FFP, or gelatins versus crystalloids probably makes little or no difference to mortality."

In a Cochrane analysis from 2018 titled *Colloids versus Crystalloids for Fluid Resuscitation in Critically Ill People*, the preponderance of the studies demonstrates that using starches, dextrans, albumin, FFP, or gelatins versus crystalloids probably makes little or no difference to mortality. Starches probably slightly increase the need for blood transfusions and renal replacement therapy. Albumin or FFP may make little or no difference to the need for renal replacement therapy. Evidence for blood transfusions for dextrans, albumin or FFP, is uncertain. Similarly, evidence for adverse events is uncertain.[3] Therefore, the choice between crystalloids and colloids appears to be up to the individual administering it.

The crystalloid of choice should be an **isotonic, balanced crystalloid** (lactated ringer's, hartman's, plasmalyte). The electrolytes contained in the solution should closely mimic the blood plasma. It is important to note that 0.9% normal saline is NOT a balanced salt solution since it only contains Na+ and Cl- in equal parts, and we know that large volumes of saline (30 ml/kg/hr or greater) can cause hyperchloremic metabolic acidosis.

So, why does normal saline lead to a metabolic acidosis? It is based on the strong ion difference (SID) within the body. (SID = [strong cations] – [strong anions] = [Na+ + K+ + Ca2+ + Mg2+] – [Cl- + lactate-]). Disturbances that increase the SID increase the blood pH (alkalosis) while disorders that decrease the SID lower the plasma pH (acidosis). Hyperchloremia caused by large volumes of normal saline decreases the SID leading to hyperchloremic metabolic acidosis due to movement of bicarbonate (a weak anion) intracellularly or bicarbonate wasting through the kidneys to reestablish the normal SID.

This has been demonstrated clinically in a study from 2001 titled *Normal Saline versus Lactated Ringer's Solution for Intraoperative Fluid Management in Patients Undergoing Abdominal Aneurysm Repair: An Outcome Study*. When normal saline was used as the primary intraoperative solution, significantly more acidosis was seen on completion of surgery. This acidosis resulted in no apparent change in outcome but required larger amounts of bicarbonate to achieve predetermined measurements of base deficit and was associated with the use of larger amounts of blood products.[4]

Furthermore, studies also demonstrate that the use of normal saline in renal transplant patients leads to more acidosis and higher serum potassium levels when compared to balanced salt solutions. For example, a study from 2005 titled "A randomized, double-blind comparison of lactated Ringer's solution and 0.9% NaCl during renal transplantation" showed lactated ringers was associated with less hyperkalemia and acidosis compared with normal saline.[5] This is assumed to be due to the hyperchloremic metabolic acidosis leads to movement of hydrogen ions intracellularly and potassium ions extracellularly.

Lastly, we should discuss the "endothelial glycocalyx" which may be responsible for maintenance of fluid homeostasis. It is a jelly-like protective layer made of mostly glycosylated proteins covering the luminal surface of the endothelium. It is the molecular barrier for plasma proteins. Perioperative damage to the glycocalyx increases vascular permeability leading to interstitial fluid shifts, edema, platelet aggregation, leukocyte adhesion, creation of a prothrombotic environment and increased surgical morbidity. Pathological shedding of the glycocalyx occurs in response to hypervolemia (endovascular expansion), endotoxins, inflammatory mediators, atrial natriuretic peptide, ischemia-reperfusion injury, oxygen free radicals and hyperglycemia. Protecting this structure during surgery means limiting the surgical trauma and avoiding intravascular hypervolemia. Hypervolemia induces a significant amount of protein movement into the interstitial space. Studies show that most of the proteins in colloids are lost during hypervolemic administration, however, most, or all stay in the intravascular space during euvolemic hemodilution.[6,7]

I hope that after reading this, you will never look at fluid administration in the operating room the same way. You will be hanging a medication no different than any other infusion of say norepinephrine, vancomycin or propofol with the ability to benefit or hurt the patient depending on how administered.

References

1) Quinn TD, Brovman EY, Urman RD. Analysis of Variability in Intraoperative Fluid Administration for Colorectal Surgery: An Argument for Goal-Directed Fluid Therapy. J Laparoendosc Adv Surg Tech A. 2017 Sep;27(9):892-897.
2) M. Lilot, J. M. Ehrenfeld, C. Lee, B. Harrington, M. Cannesson, J. Rinehart, Variability in practice and factors predictive of total crystalloid administration during abdominal surgery: retrospective two-centre analysis, *BJA: British Journal of Anaesthesia*, Volume 114, Issue 5, May 2015, Pages 767–776.
3) Lewis SR, Pritchard MW, Evans DJW, Butler AR, Alderson P, Smith AF, Roberts I. Colloids versus crystalloids for fluid resuscitation in critically ill people. Cochrane Database of Systematic Reviews 2018, Issue 8. Art. No.: CD000567.
4) Waters JH, Gottlieb A, Schoenwald P, Popovich MJ, Sprung J, Nelson DR. Normal saline versus lactated Ringer's solution for intraoperative fluid management in patients undergoing abdominal aortic aneurysm repair: an outcome study. Anesth Analg. 2001 Oct;93(4):817-22.
5) O'Malley CM, Frumento RJ, Hardy MA, Benvenisty AI, Brentjens TE, Mercer JS, Bennett-Guerrero E. A randomized, double-blind comparison of lactated Ringer's solution and 0.9% NaCl during renal transplantation. Anesth Analg. 2005 May;100(5):1518-24.
6) Rehm M, Orth VH, Kreimeier U, Thiel M, Mayer S, Brechtelsbauer H et al. Changes in blood volume during acute normovolemic hemodilution with 5% albumin or 6% hydroxyethylstarch and intraoperative retransfusion. Anaesthesist 2001; 50:569-579. 57.
7) Rehm M, Haller M, Orth V, Kreimeier U, Jacob M, Dressel H et al. Changes in blood volume and hematocrit during acute preoperative volume loading with 5% albumin or 6% hetastarch solutions in patients before radical hysterectomy. Anesthesiology 2001; 95:849-856.

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Continuing Education Quiz

To test your knowledge on this issue's article, provide correct answers to the following questions on the form below. Follow the instructions carefully.

1. Normal saline is the preferred fluid for resuscitation.
a. True
b. False

2. Colloids are always preferred over crystalloids in all patients.
a. True
b. False

3. Regarding arterial vascular lining, endothelial glycocalyx is important to:
a. assist in transfer of fluids in the interstitial space.
b. keep proteins out of vessels.
c. maintain fluid homeostasis
d. allow laminar flow of blood.

4. Which IV fluid may cause metabolic acidosis?
a. Albumin
b. Lactated ringers
c. Normal saline
d. Plasmalyte

5. Kidney transplant patients should be given normal saline:
a. True
b. False

6. IV Albumin is a colloid:
a. True
b. False

7. Which is not a balanced salt solution?
a. Lactated ringers
b. Normal Saline
c. Plasmalyte
d. Normosol-R

8. Hyperchloremia causes a metabolic acidosis.
a. True
b. False

9. Hypervolemia cannot disrupt the endothelial glycocalyx.
a. True
b. False

10. Which is not a colloid:
a. Gelatin
b. Albumin
c. Lactated ringers
d. Blood

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(circle answers)

1:	A B	**6:**	A B
2:	A B	**7:**	A B C D
3:	A B C D	**8:**	A B
4:	A B C D	**9:**	A B
5:	A B	**10:**	A B C D

Quiz 1 of 2

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