Fluid Administration in the Operating Room: An Update Focusing on Recent Literature

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Starting off the session on fluid administration in the operating room, Andrew Leibowitz, MD, Icahn School of Medicine at Mount Sinai, New York, New York, USA, presented an overview entitled "Monitoring and Optimizing Intravascular Volume." His review addressed current knowledge of fluid administration and a summary of data on the use of different monitoring approaches and devices.

To balance the risks of giving too much or too little fluid, it is important to carefully consider the comorbidities and status of the patient (eg, a healthy patient may respond differently than one who is elderly and critically ill) as well as the risks and benefits of hyper- and hypovolemia. Additionally, it is important to realize that almost 50% of patients who are hypotensive in the operating room do not experience increases in cardiac output or blood pressure following fluid administration.

To achieve the correct level of hydration, it is important to find ways to determine when fluids are beneficial. For example, common indicators (eg, blood pressure) are not effective, and increased lactate levels do not necessarily indicate hypoperfusion (many other possible reasons exist).

While central venous pressure can be measured, it does not correlate with blood volume, and there is no cutoff that determines whether patients are likely to respond to fluid administration [Marik PE et al. *Chest*. 2008]. Even in healthy volunteers, change in central venous pressure is not correlated with blood volume [Kumar A. *Crit Care Med.* 2004]. Additionally, cardiac output is not a reliable measure, because it is variable and not correlated with outcomes. There is no evidence that it is beneficial to increase cardiac output (which can cause adverse effects through increasing heart rate); one reason that pulmonary artery catheters have not improved outcomes is that they do not provide relevant information.

Several devices have been developed to show cardiac output derived from pulmonary artery catheters. These devices give imprecise measurements (eg, the true cardiac output could be >30% above or below the measurement shown by the device), and they have been tested on average patients rather than those who are critically ill.

To know when it is beneficial to provide fluid volume, Dr Leibowitz recommends examining arterial pressure changes. A systolic pressure change >13% suggests that a patient will respond favorably to a fluid challenge, causing an increase in blood pressure, while patients with changes <9% are not likely to respond. Patients in the middle range fall into a gray zone in which clinical judgment is needed. The limitations of this approach are that it can be used only if a patient is on mechanical ventilation, has a tidal volume greater than 8 mL/kg, and has a sinus rhythm.

Various devices have been developed, including $PiCCO_2$, LiDCO Plus, LiDCO Rapid, and Flotrac/Vigileo, and they have limitations—for instance, these devices do not show output that is within 30% of the patient's real output (considered an important criterion for acceptability). In summary, Dr Leibowitz encouraged clinicians to be skeptical and to use arterial pressure changes to make decisions about fluids, realizing that the utility of other approaches (including new devices) is unclear.

Following Dr Leibowitz' s introductory talk, John E. Ellis, MD, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania, USA, gave a presentation on the use of colloids and crystalloids in intensive care unit (ICU) and operating room environments.

Trials and meta-analyses have been conducted to compare fluids [Myburgh JA, Mythen MG. *N Engl J Med.* 2013]. In the ICU, albumin and saline result in similar survival probabilities

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[Finfer S et al. *N Engl J Med.* 2004]. Colloid and crystalloid are associated with similar outcomes in critically ill patients with hypovolemic shock [Annane D et al. *JAMA*. 2013]. However, some possible adverse events have been reported. Albumin may be associated with worse outcomes in patients with traumatic brain injury. Additionally, hydroxyethyl starch may be associated with complications involving coagulation and acute kidney injury [Zarychanski R et al. *JAMA*. 2013]. According to Dr Ellis, hydroxyethyl starch is not frequently used now, except for goal-directed fluid therapy [Gan TJ et al. *Anesthesiology.* 2002].

In making decisions about fluids, it is important to consider the glycocalyx [Chapell D, Jacob M. *Best Pract Res Clin Anaesthesiol.* 2014]. The glycocalyx affects the pressure in the interstitial space, is involved in transport, forms a barrier, and acts as a sensor. When it is damaged (eg, by ischemia), leakage can occur. Prophylactic hypervolemia can damage the glycocalyx and increase risks. If intravascular hypovolemia is the only issue, meaning that the glycocalyx is intact, then isoncotic albumin and hydroxyethyl starch are more effective.

In summary, Dr Ellis mentioned that albumin should not be used with traumatic brain injury and that hydroxyethyl starch should not be used in sepsis or when there is a risk of acute kidney injury. However, the safety of many of these fluids has not been definitively established, and it is not clear whether crystalloid or colloid is better in general. Fluid recommendations may differ in the operating room, because more fluid could help ambulatory patients recover with fewer side effects, while having fewer of the negative consequences affecting high-risk patients in the ICU.

Continuing the discussion of fluid choices, Michael H. Wall, MD, University of Minnesota, Minneapolis, Minnesota, USA, gave a presentation entitled "Are Synthetic Colloids Safe?" After summarizing the types of colloids and how they are named, he described ways that their structures affect their metabolism (eg, larger ones are metabolized while smaller ones are rapidly excreted) [Westphal M et al. *Anesthesiology.* 2009]. In addition to differing in structure, synthetic colloids differ in source (waxy maize vs potatoes) and in solvents.

A range of safety concerns has been voiced. Colloids may influence coagulation and platelet function and may affect renal function, among other issues. Additionally, there is a lack of data on their effects on elderly individuals, children, and patients with renal disease.

While the results have been mixed, studies have not shown clinical benefits for one colloid, hydroxyethyl starch, and some have suggested substantial risks (especially to kidneys) [Gillies MA et al. *Br J Anaesth.* 2014; Serpa Neto A et al. *J Crit Care*. 2014]. Dr Wall opined that, based on the current evidence, synthetic colloids are not safe for us.

Steven G. Venticinque, MD, University of Texas Health Science Center, San Antonio, Texas, USA, concluded the session with his presentation "Choosing the Correct Colloid," which focused on risks of normal saline solution.

Dr Venticinque began by providing some history and explaining the Stewart approach to acid-base chemistry to explain why normal saline can cause hyperchloremic acidosis. He then summarized multiple studies showing that normal saline can cause negative effects that are not caused by balanced solutions (eg, lactated Ringer's solution). He suggested that a more balanced solution could be developed with an organic anion that can be metabolized but lacks excess ions, such as calcium, magnesium, and potassium.

Saline is often considered important for patients with elevated potassium and renal failure, brain injury and elevated intracranial pressure, and blood transfusion compatibility issues. However, there is evidence that even these patients are not helped by saline solutions when compared with balanced solutions [Roquilly A et al. *Critical Care.* 2013; Levac B et al. *Can J Anaesth*. 2010; Albert K et al. *Can J Anaesth*. 2009; Hadimioglu N et al. *Anesth Analg*. 2008; Khajavi MR et al. *Ren Fail*. 2008; Cruz RJ Jr et al. *Anesth Analg.* 2006; Cull DL et al. *Surg Gynecol Obstet.* 1991]. One major problem with using saline is that it is confounds interpretation of blood gases when they are used as an index of resuscitation. Recent British consensus guidelines state that balanced solutions should be used in place of saline for adult patients receiving intravenous therapy, except for the specific case of hypochloremia [Soni N. *Anaesthesia*. 2009].

In conclusion, Dr Venticinque cautioned that normal saline can cause non–anion gap acidosis and hyperchloremia and can potentially act as a confounding factor during resuscitation. For these reasons, he thinks that it may be harmful in many situations in which it is currently being used.