Postoperative Fluid and Electrolyte Therapy

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"La fixité du milieu intérieur est la condition d'une vie libre et indépendante"

- Unicellular organisms isotonic with their environment—the sea
- The cells of most “higher” organisms “float in their internal sea”—extracellular fluid

Claude Bernard 1813-1878

Physiologic Regulation of the “Milieu Intérieur”

Ernest H. Starling 1866-1927

Homeostasis

- The physiologic processes necessary for maintenance of the “internal environment

Walter B. Cannon 1871-1945
Primordial Sea

- Large Volume of Water
- High Specific Heat of Water
- Depth of Water (except in coastal areas)

All prevented wide fluctuations in Temperature and composition of the environment of the unicellular organisms.

Electrolyte Concentrations of Sea Water and Extracellular Water

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Sea Water</th>
<th>Extracellular Water</th>
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<tbody>
<tr>
<td>Na</td>
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<td></td>
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<td>K</td>
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<td>Cl</td>
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<td>HCO₃</td>
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<td>HPO₄</td>
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<tr>
<td>SO₄</td>
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Total Body Water

Total Body Water = Intracellular Water + Extracellular Water
42 liters = 28 liters + 14 liters

Restoration of Intravascular Volume by Osmosis

Influx of Intracellular Fluid to Extracellular Space

Increased Osmotic Pressure

Neuroendocrine Response to Hypovolemia

Influx of ECF to Vascular Space

Increased Blood Volume
Renin-Angiotensin System

Atrial Naturetic Peptide

Henderson-Hasselbach Equation

Carl J Wiggers, MD

\[ \text{pH} = pK + \log \frac{[A]}{[HA]} \]

\[ \text{pH} \alpha \frac{\text{HCO}_3}{\text{H}_2\text{CO}_3} \]

\[ \text{pH} \alpha \frac{\text{HCO}_3}{\text{H}_2\text{CO}_3} = \frac{\text{HCO}_3}{\text{CO}_2} \]

Alterations in Cellular Membrane Function During Hemorrhagic Shock in Primates


Trans saccar or hemorrhagic shock on the functional integrity of the cell membrane is currently under active investigation in many areas. The analysis of changes occurring in a cellular level in anesthesia with a low flow state has previously been limited by the lack of techniques for directly measuring the regulatory function of the cell membrane. As a result, present data consist largely of information obtained through implementation of indirect methods for evaluation of altered cellular function. More recently, however, the availability of accurate methods for directly assessing physiologic changes occurring at a cellular level has allowed for a more subtle interpretation of alterations in transport occurring in hemorrhagic shock.

The current use of ultramicroelectrodes to monitor transmembrane potential differences (PM) has proven to be an extremely useful technique in accurately assessing cellular membrane function in response to hemorrhagic shock.

Methods and Materials

Non-sedated, anesthetized adult baboons (Papio spp.) weighing 10–12 kg were anesthetized initially with a combination of ketamine (20 mg/kg) and Pentothal (5 mg/kg) and maintained on small doses of Pentothal throughout the experiment to achieve a constant level of anesthesia. Tracheostomy was performed. Pulmonary catheters were used to control and

Ann Surg 1972;176:288-293

Starling Forces


Alfred Blalock

Walter B. Cannon
The Phenomenon of “Fluid Creep” in Acute Burn Resuscitation

Jeffrey R. Saffie, MD, FACS

Several reports have documented that modern burn patients receive more resuscitation fluid than predicted by the Parkland formula—a phenomenon termed “fluid creep.” This article reviews the incidence, consequences, and possible mitigations of fluid creep in modern practice and uses this information to propose some hypotheses: attempts to reduce or eliminate excessive fluid resuscitation in burn care. A literature review was performed of historical references that date from the development of modern fluid resuscitation, as well as reports of fluid creep and its consequences. The original Parkland formula required a 24-hour volume of 4 ml/kg NS (NS = normal saline) followed by an infusion of 0.5–0.7 ml/kg NS (NS = NS + 5% dextrose/glucose).

J Burn Care & Research 2007;28:382-395

Adverse Surgical Effects of Overzealous Fluid Therapy?

Critical care medicine 1999; 27:2142-6

Postoperative fluid and electrolyte balance: alarming audit results

J Perioper Pract 2009;19:291-4


Arch Surg 2003;138:1055-1060

Curr Opin Clin Nutr Metab Care 2004;7:27-33

Int J Colon Rectal Dis 2009;24:699-709
Association of Perioperative Fluid Balance and Adverse Surgical Outcomes in Esophageal Cancer and Esophagogastric Junction Cancer

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Department of Thoracic Surgery, First Hospital of Tsinghua University, Beijing, China

Background: Perioperative fluid balance and its association with surgical outcomes in patients with esophageal and esophagogastric junction cancer have not been clearly elucidated. A retrospective study of this association was conducted.

Methods: A retrospective study involving 96 patients undergoing transhiatal esophagectomy in esophageogastrectomy was conducted. The perioperative and postoperative fluid gains and outputs as well as perioperative morbidity and mortality were recorded. Univariate analysis and multivariate logistic regression analysis were performed to clarify the effect of fluid balance on postoperative outcomes.

Results: There were 76 men and 21 women with an average age of 61.3 ± 10.9 years in the study. Among them, 61 patients had esophageal cancer and 35 had esophagogastric junction cancer. The perioperative mortality and morbidity were 3.2% and 7.3%, respectively. Compared with normal outcomes, adverse surgical outcomes were significantly related to larger fluid balance on postoperative day 1 and day 2, and to cumulative fluid balance from the intraoperative period to postoperative day 5 (AUC = 0.763 vs. 0.683, p = 0.002). Univariate logistic regression analysis, cumulative fluid balance from intraoperative period to postoperative day 2 was independently related to adverse surgical outcomes (B = 0.22, 95% confidence interval: 0.009 to 0.43, p = 0.051).

Conclusion: The cumulative fluid balance from the intraoperative period to postoperative day 2 is a good predictor of surgical outcomes. It can be used as a prognostic tool to evaluate the risk of adverse surgical outcomes.


Impact of Different Crystalloid Volume Regimes on Intestinal Anastomotic Stability

Gawan Marzouk, MD * Christian Villain, * Eva Austre * Axel van Hasselt, MD, PhD * Jens Hoeggaard, MD, Ulrik Theodor Hojs, MD * Oliver Dignitz, MD * and Robert Obermaier, MD *

Background: Aortic anastomotic instability still ranks as a crucial problem in abdominal aortic reconstruction. Current guidelines recommend perioperative crystalloid loading to minimize risk of anastomotic leakage. However, different studies have presented varying results on the optimal volume-regimen to achieve optimal stability of the anastomosis in the perioperative period.

Methods: Forty-five patients undergoing open and hybrid aortic reconstructive procedures were prospectively randomized to receive either 2.5 L of 0.9% NaCl or 2.5 L of a combination of 0.9% NaCl and 0.45% NaCl, each infused over 6 hours and divided into 3 equal portions. Each patient was stratified into a control group (2.5 L of 0.9% NaCl) and a combination group (2.5 L of 0.45% NaCl + 0.9% NaCl). Intraoperatively, anastomotic leakage was defined as leakage exceeding 10 mL. Intestinal stability was measured using a fluid replacement ratio (FRR), defined as the ratio of intraoperative volume infusion to fluid deficit.

Results: The FRR was significantly lower in the combination group compared to the control group (p < 0.05). Additionally, the incidence of anastomotic leakage was significantly lower in the combination group (5% vs. 20%, p < 0.05).

Conclusion: The results of this study suggest that a combination of 0.45% NaCl and 0.9% NaCl may provide superior intestinal stability during open and hybrid aortic reconstructive procedures compared to 0.9% NaCl alone. Further studies are needed to confirm these findings and to determine the optimal volume regimen for minimizing anastomotic leakage.


Effect of salt and water balance on recovery of gastrointestinal function after elective colorectal resection: a randomized controlled trial

Some authors have suggested that an increase in salt and water balance during surgery may promote faster recovery of gastrointestinal function. The aim of the study was to investigate whether administering a higher sodium content than standard saline solution (SS) influences the rate of recovery of gastrointestinal function in patients undergoing elective colorectal resection.

Methods: Patients undergoing elective colorectal resection were randomized to receive either 0.9% NaCl (SS) or 0.15% NaCl (NS) for intraoperative fluid management. The primary outcome measure was the time to first flatus and bowel movement. Other variables such as fluid balance, wound complication rate, and length of stay were also recorded.

Results: A total of 120 patients were included in the study, with 60 in each group. The time to first flatus and bowel movement was significantly shorter in the NS group compared to the SS group (p < 0.05). Additionally, the fluid balance was significantly higher in the NS group (p < 0.05). There were no significant differences in wound complication rate or length of stay between the two groups.

Conclusion: The results of this study suggest that administering a higher sodium content than standard saline solution during surgery may promote faster recovery of gastrointestinal function in patients undergoing elective colorectal resection. Further studies are needed to confirm these findings and to determine the optimal sodium content for improving recovery.
**Effect of Fluid on Intestinal Anastomosis Stability**

![Graph showing the effect of fluid on intestinal anastomosis stability](image)


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**Monitoring of peri-operative fluid administration by individualized goal-directed therapy**

M. Bonuccelli-Nuccio, K. Harvey, N. H. Secor, and H. Kruse.

Surgery, injury and systemic infection result in injury to cell membranes resulting in leakage of fluid into the interstitium. Overzealous crystalloid infusion decreases plasma oncotic pressure exacerbating fluid leakage into the interstitium.

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**Summary**

- Evolution favors retention of salt and water in humans via osmosis and the neuroendocrine system
- Surgery, injury and systemic infection result in injury to cell membranes resulting in leakage of fluid into the interstitium
- Overzealous crystalloid infusion decreases plasma oncotic pressure exacerbating fluid leakage into the interstitium

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**What can we do to control "Fluid Creep"?**

- Restrict Early Fluid Resuscitation
- Consider Blood/Colloid Resuscitation early as indicated
- Monitor Resuscitation
- Use Fluid Resuscitation Protocols
- Hypertonic Saline???


Last Accessed January 14, 2011
Conclusion

• More careful attention to monitoring
• Replacement of blood loss with blood
• ? Perioperative Fluid Protocols

are likely to result in improved outcomes for our patients