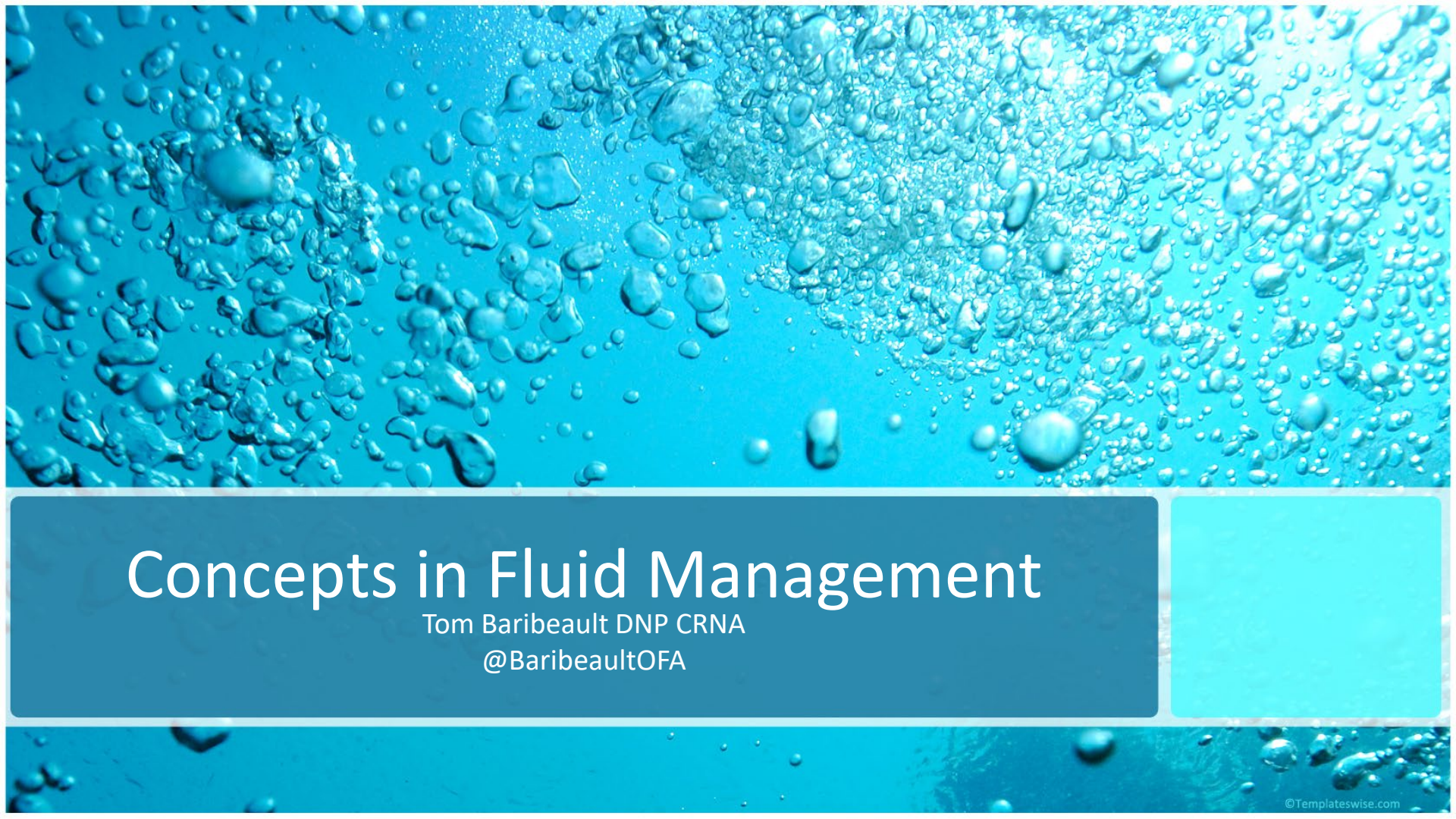
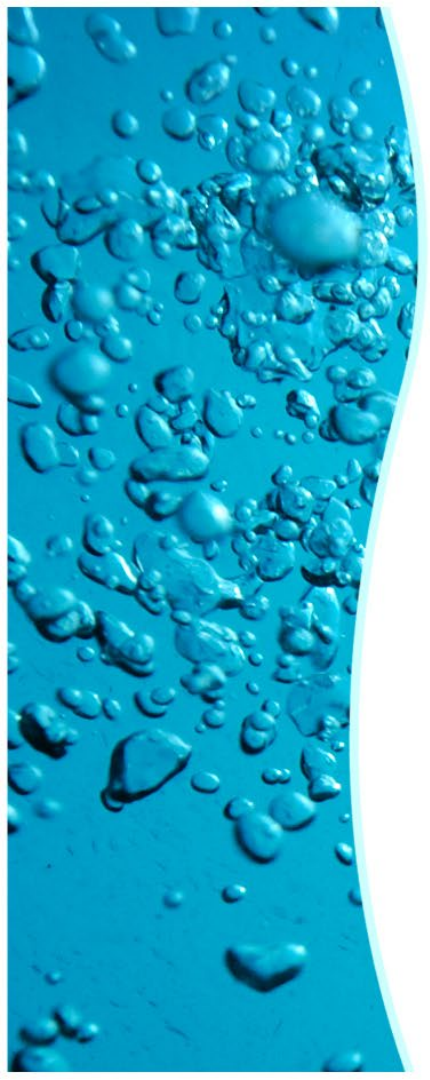


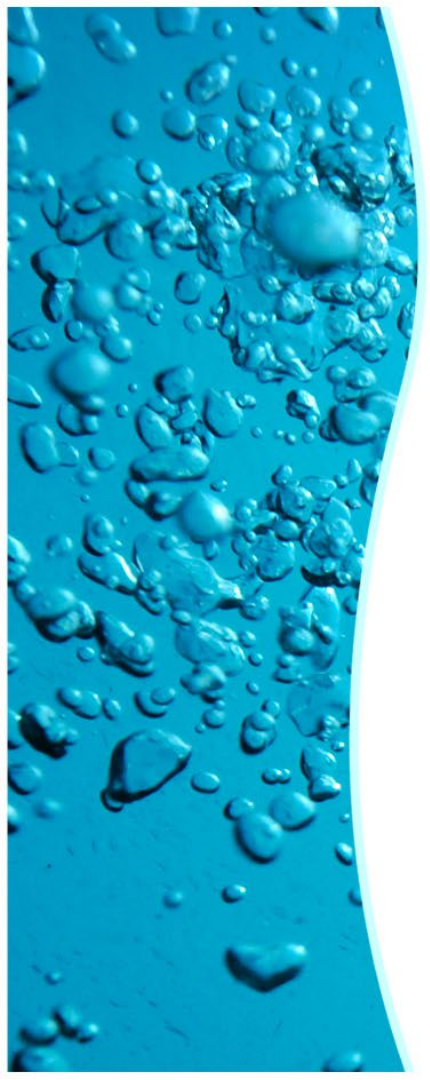
Concepts in Fluid Management

Tom Baribeault DNP CRNA
@BaribeaultOFA



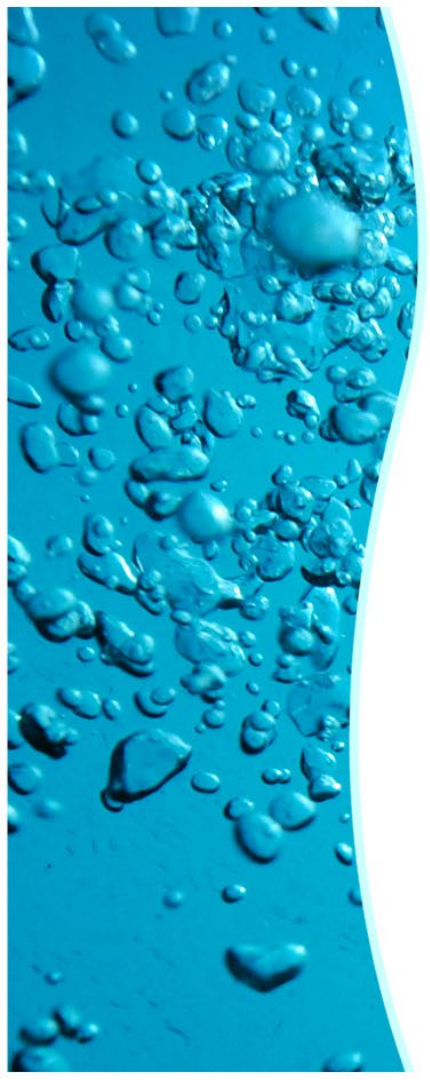
Problems

- Lack of definitions
- Lack of protocol consistency between studies
- Most studies don’t address post-op fluid management



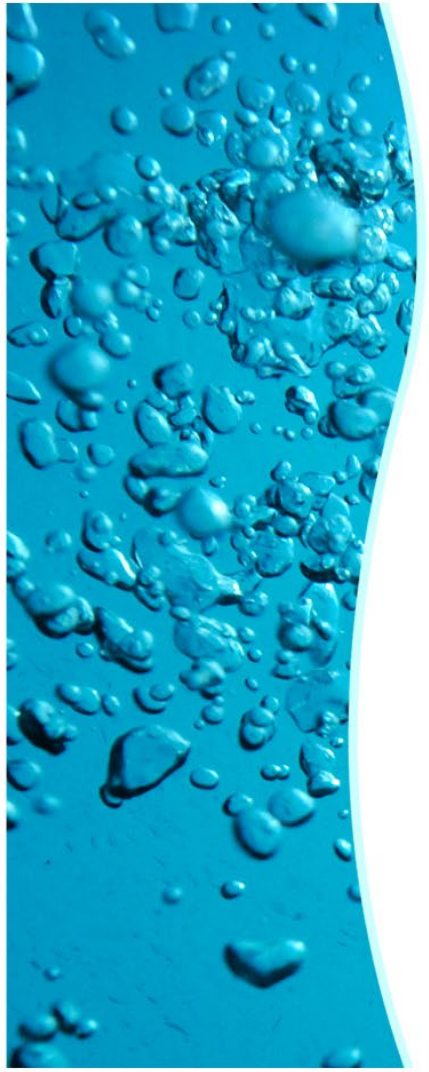
Definitions

- Liberal or Traditional
  - 4-2-1 maintenance rate, NPO deficit, 3:1 blood loss, 2-10 ml/kg/hr evaporative loss
- Restrictive
  - Less than Liberal
- Zero Balance
  - Euvolemia
- Goal directed
  - Near maximal stroke volume



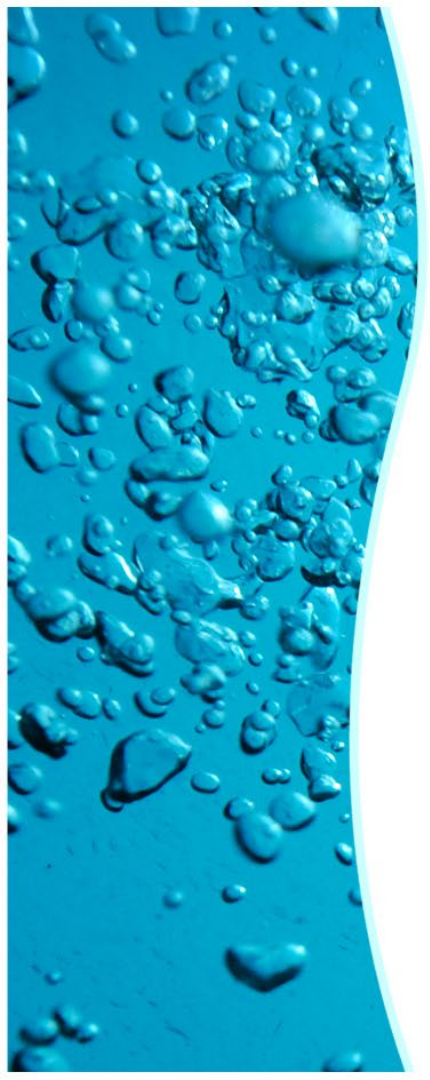
Fluid management and goal-directed therapy as an adjunct to ERAS

- Pre-operative
  - 400 ml carbohydrate drink 2 hours prior to surgery
    - Patients fed and hydrated
    - Stomach empties completely within 90 minutes
    - Same with diabetics and obese
    - Less likely to be fluid responsive on induction of anesthesia



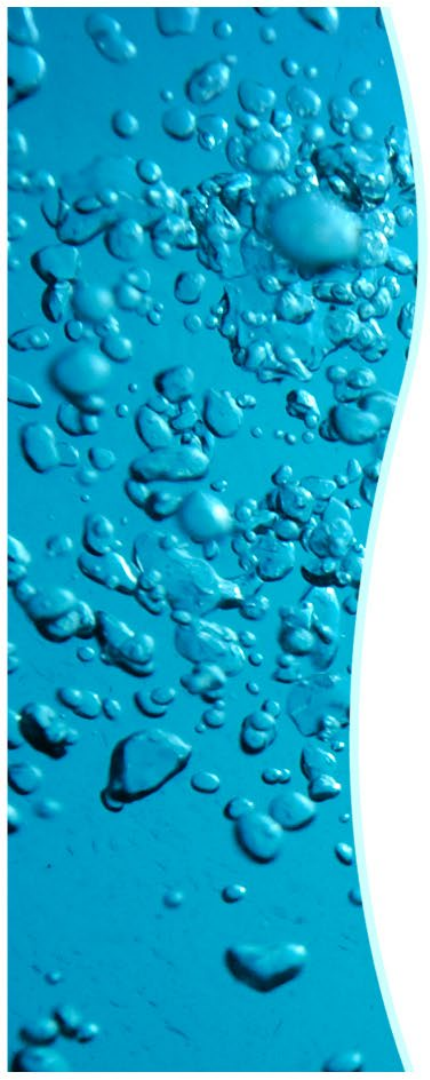
Fluid management and goal-directed therapy as an adjunct to ERAS

- Pre-operative
  - 400 ml carbohydrate drink 2 hours prior to surgery
    - Shorter hospital stay
    - Less nitrogen and protein loss
    - Decreased insulin resistance
    - Decreased thirst, hunger and anxiety



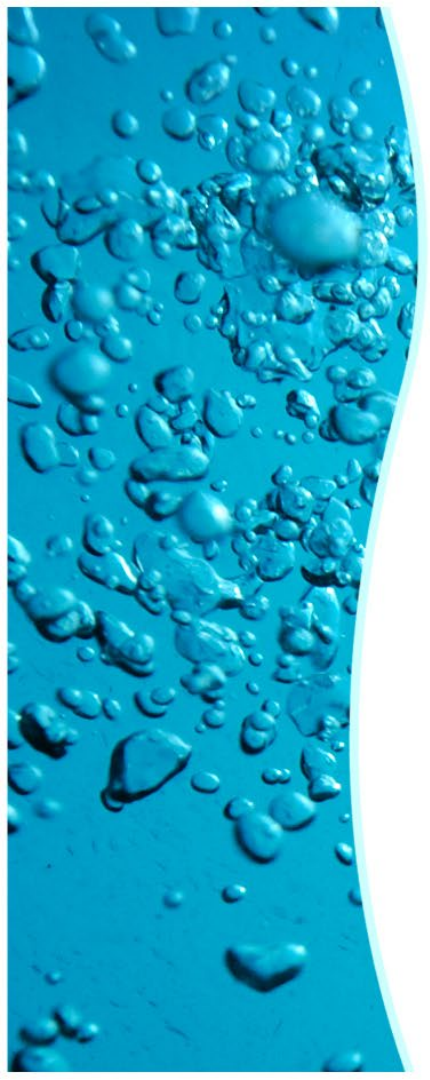
Fluid management and goal-directed therapy as an adjunct to ERAS

- Intraoperative
  - Avoid hypervolemia
    - Colon edema, ileus
    - Releases ANP, damages endothelial glycocalyx
    - Acute kidney injury
    - Weight gain of 3 kg, 5 ml/kg/hr, 3 liters of crystalloid



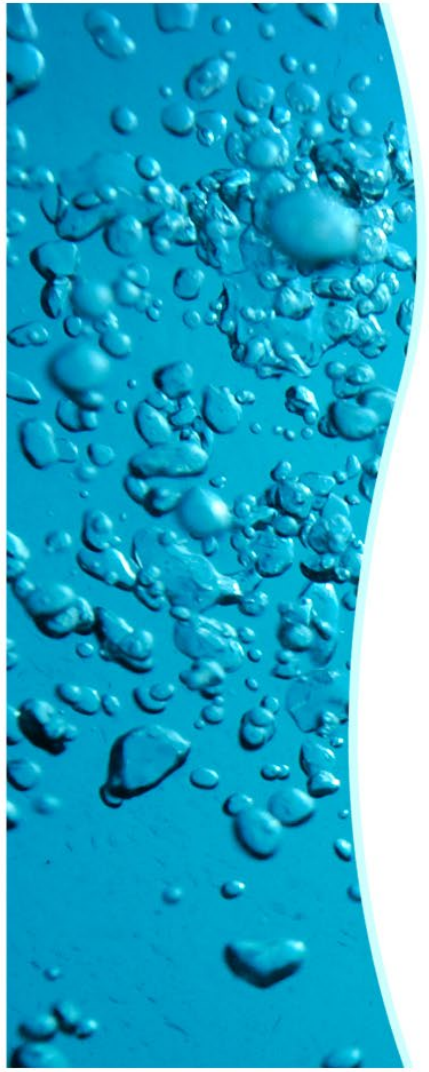
Fluid management and goal-directed therapy as an adjunct to ERAS

- Intraoperative
  - New concepts in fluid management
    - Evaporative loss
      - 0.5-1 ml/kg/hr
    - Fluid responsiveness
      - Only 50% of hemodynamically unstable patients respond to fluids
      - Volume responsiveness does not correlate with dehydration status
      - Use pressors to treat pressure



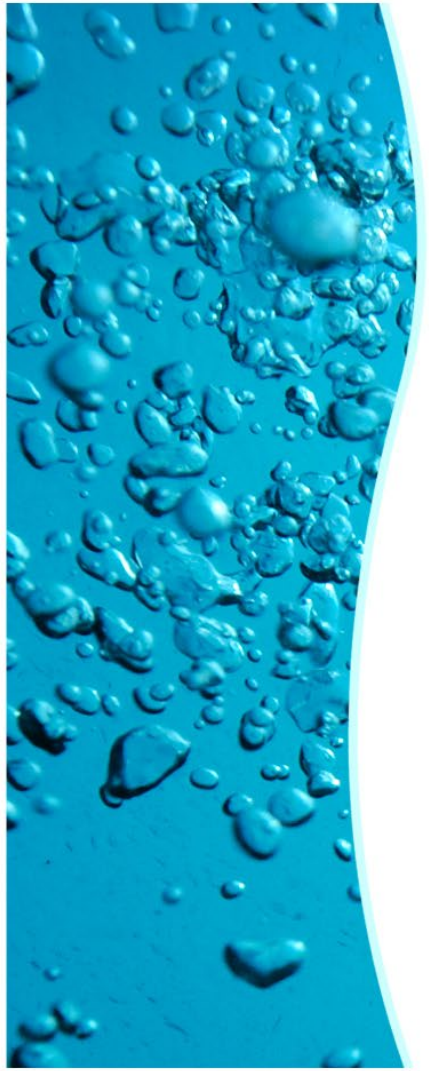
Fluid management and goal-directed therapy as an adjunct to ERAS

- Intraoperative
  - New concepts in fluid management
    - Low Intra-operative urine output
      - Not associated with fluid status
        - » Hormone release, laparoscopic surgery, hypervolemia
      - Low IUOP more common in ERAS
        - » Does not cause kidney injury
        - » Permissive oliguria



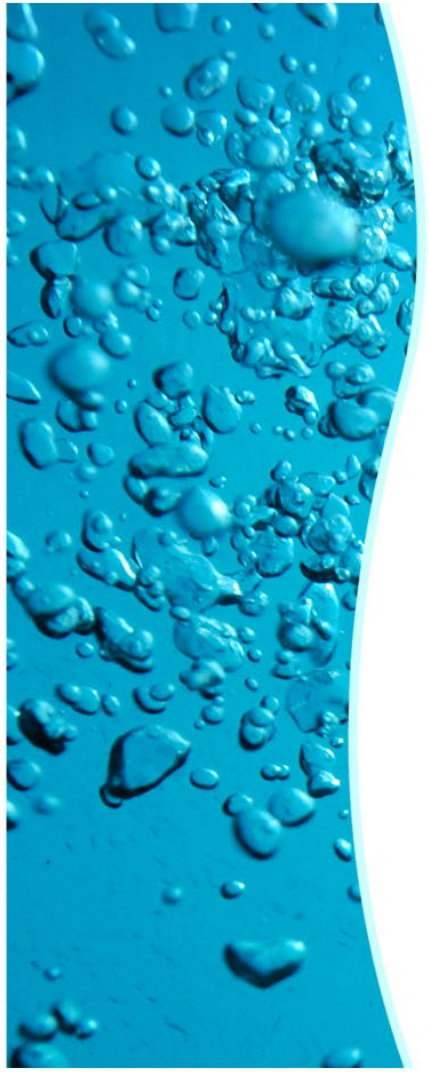
Fluid management and goal-directed therapy as an adjunct to ERAS

- Intraoperative
  - Fluid administration
    - 1-3 ml/kg/hr crystalloid
    - 1:1 colloid for blood loss
    - Fluid boluses for GDT



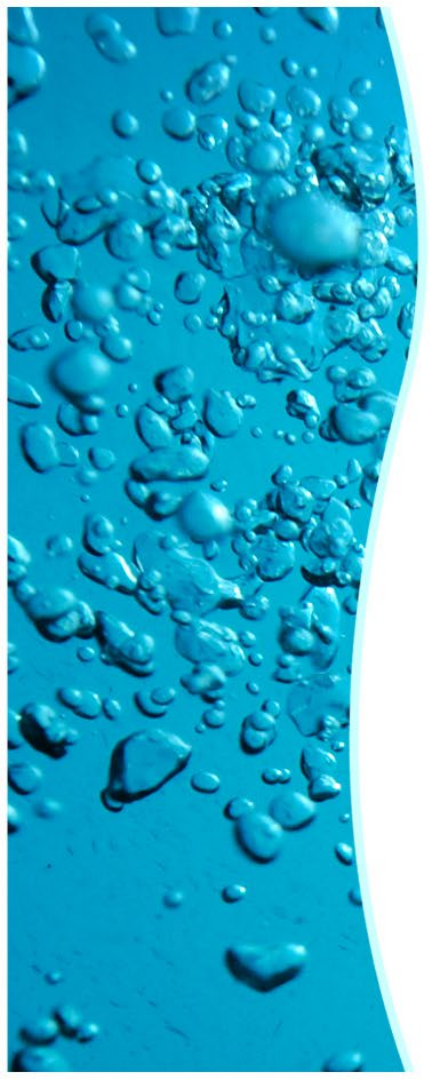
Fluid management and goal-directed therapy as an adjunct to ERAS

- Post-operative
  - Oral fluids/food as soon as tolerated
  - IV fluids only when needed



Which goal for fluid therapy during colorectal surgery is followed by the best outcome: near-maximal stroke volume or zero fluid balance?

- RCT
- Esophageal Doppler
- Colloids



Near-maximal stroke volume or zero fluid balance

- Results
  - No difference in LOS, mortality, or complications
  - Zero balance
    - No change in CO or body weight
  - Doppler
    - Increased CO, body weight increased 1.1 kg

Liberal or restrictive fluid management: are we ready for a proposal of a restricted intraoperative approach

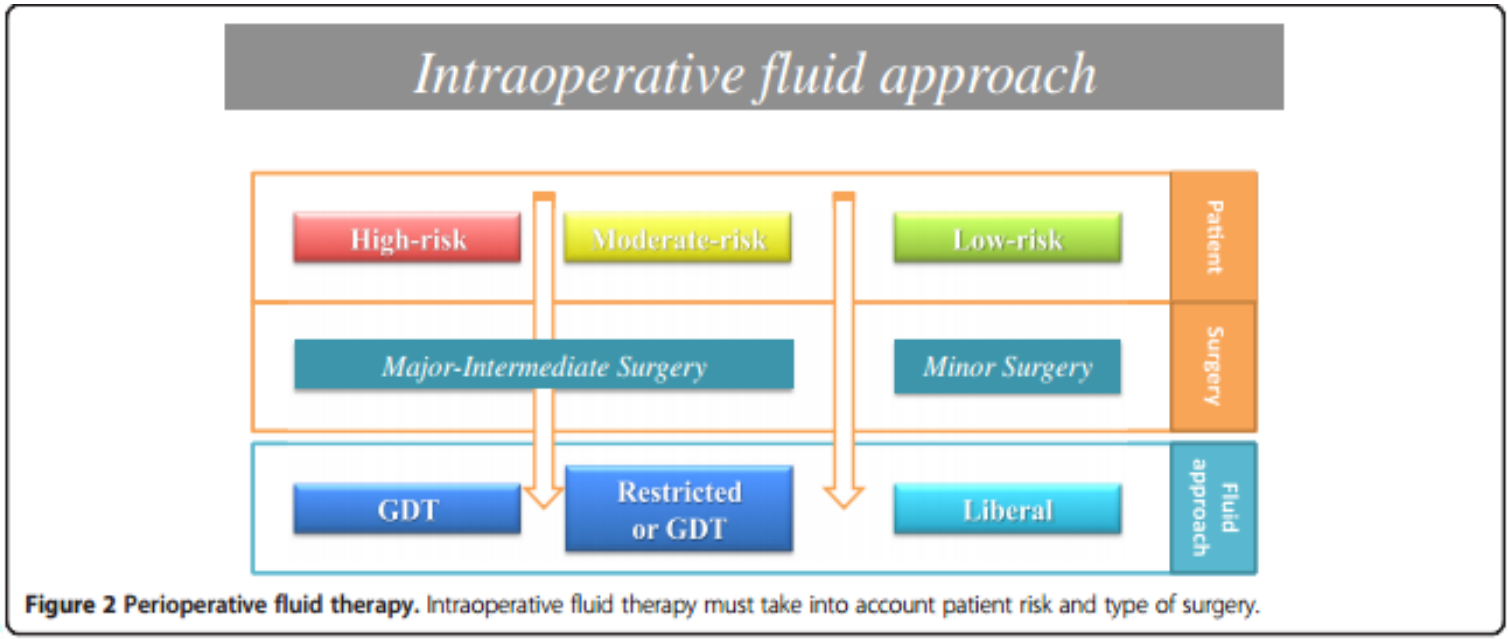


Figure 2 Perioperative fluid therapy. Intraoperative fluid therapy must take into account patient risk and type of surgery.

Liberal or restrictive fluid management

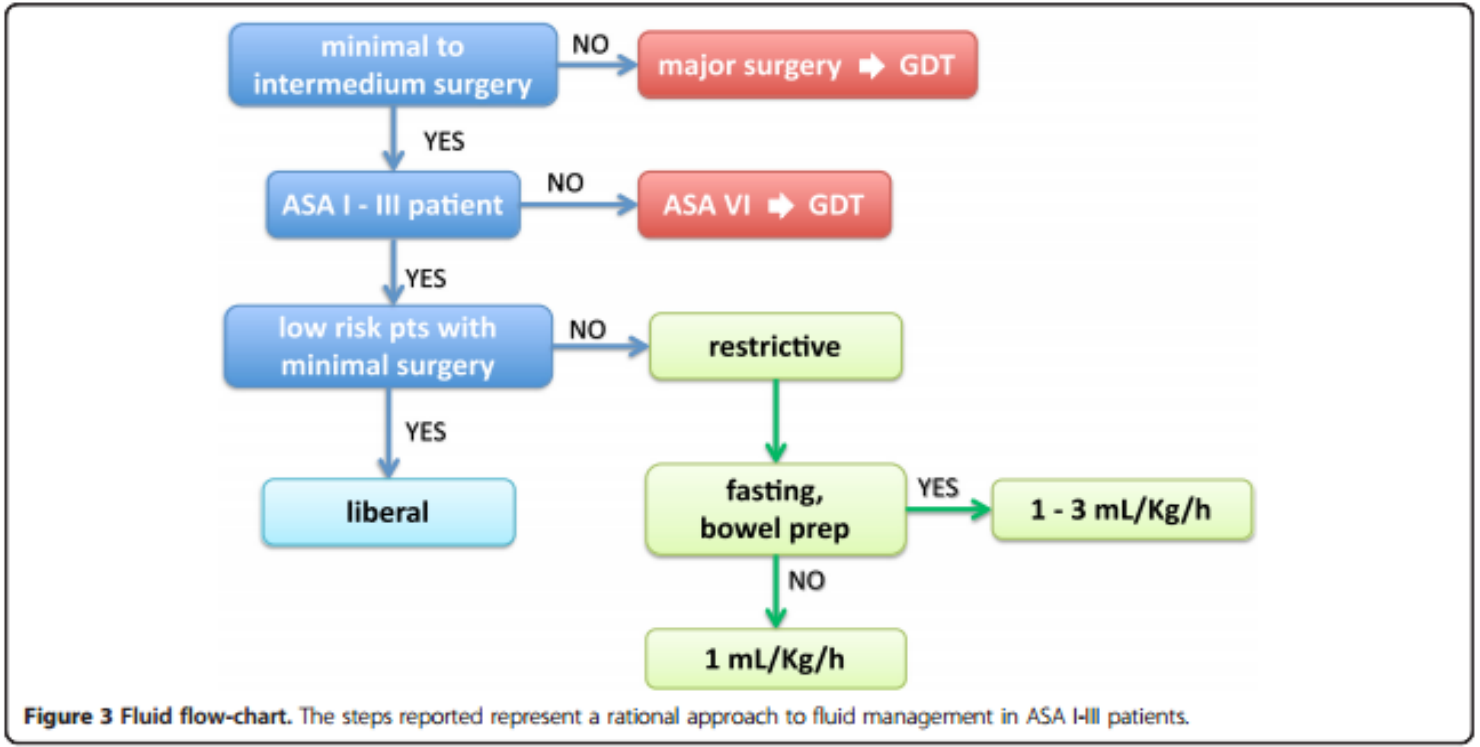
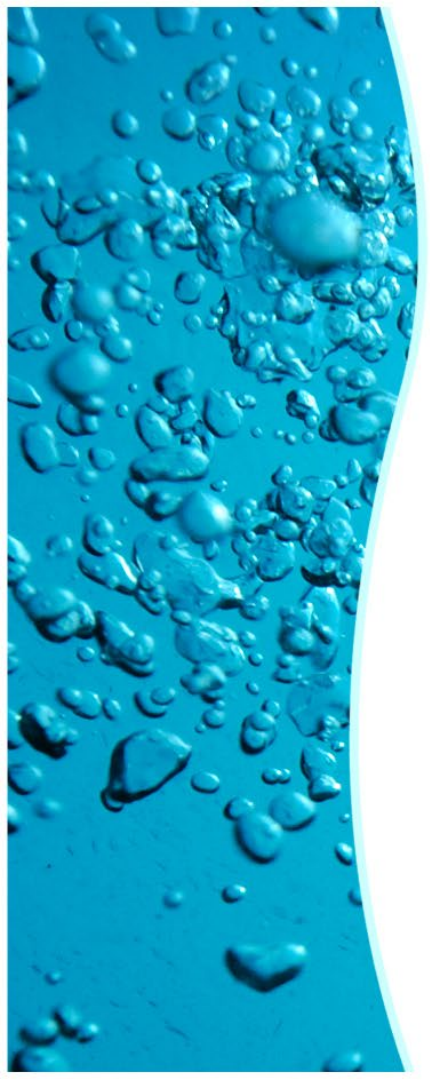
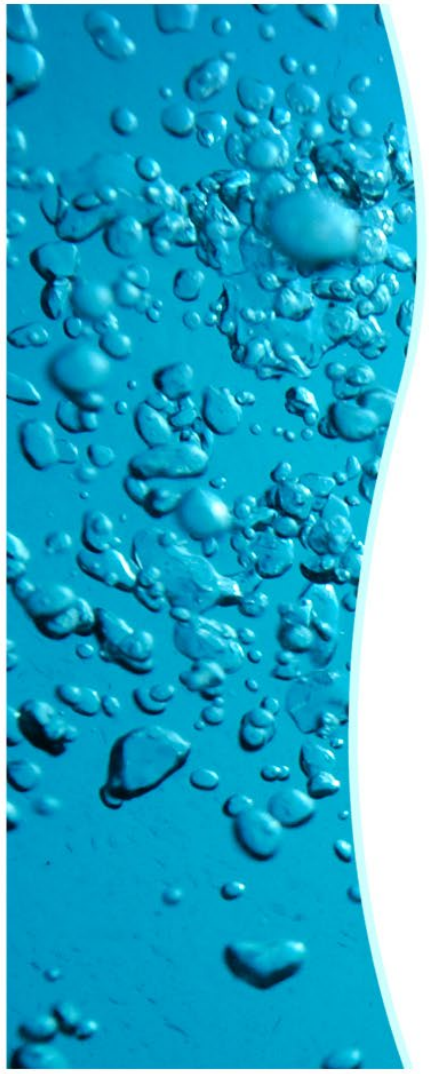


Figure 3 Fluid flow-chart. The steps reported represent a rational approach to fluid management in ASA I-III patients.



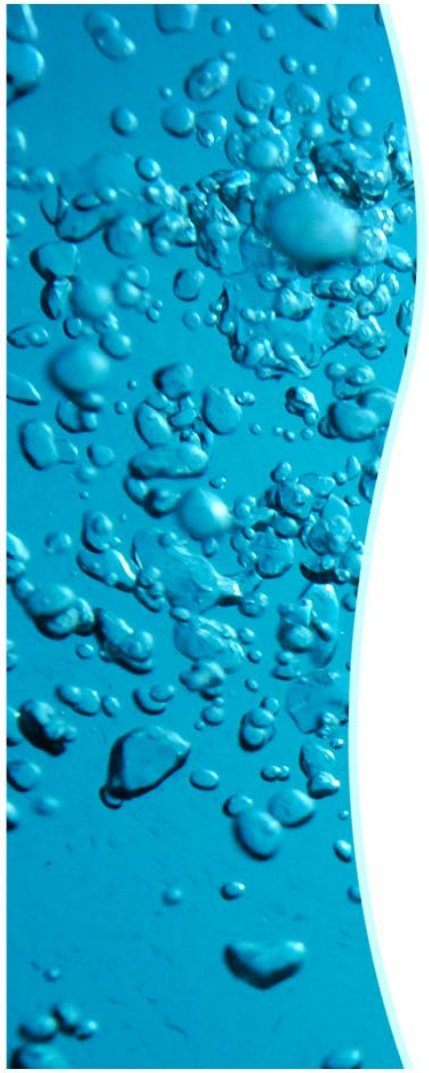
Acute Kidney Injury following implementation of an ERAS protocol in colorectal surgery

- Acute Kidney Injury
  - Urine output, BUN/creatinine
    - 11.4% vs 2.3%
    - Labs returned to normal by discharge
    - Longer surgical times



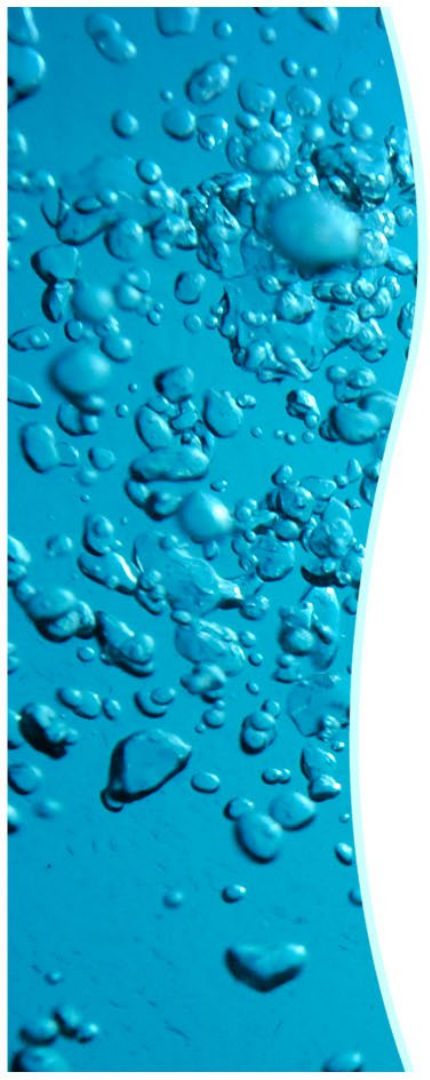
Why crystalloids will do the job in the operating room

- Summary of tracer studies and fluid kinetics
  - Effectiveness of crystalloids
- Fails to make argument against colloids
- Original tracer studies did not wait for equilibration



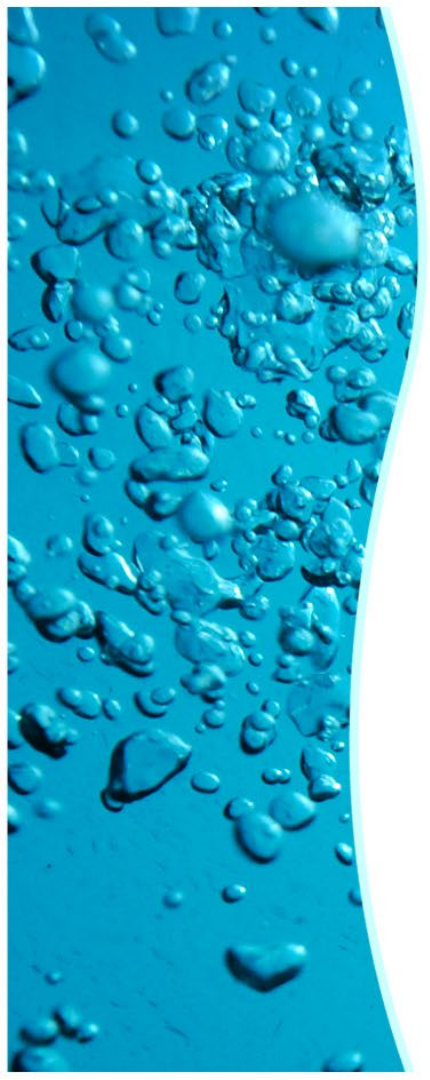
Why crystalloids will do the job in the operating room

- Slow distribution
  - 50-80% of fluid maintained in intravascular space as long as infusion is maintained
    - Previously thought to be 20%
  - Lasts until 30 minutes after infusion is d/c



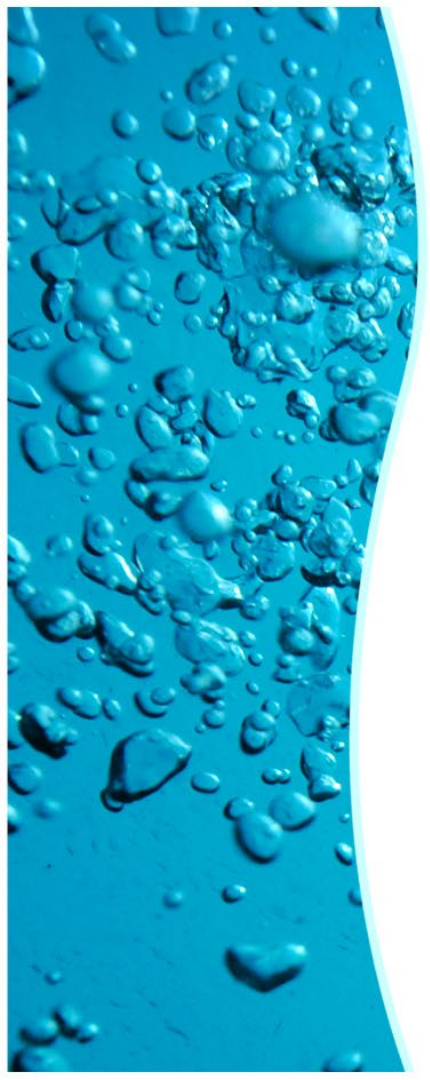
Why crystalloids will do the job in the operating room

- Arrested distribution
  - When BP falls by 20%, distribution stops completely until BP is restored for 20-30 minutes



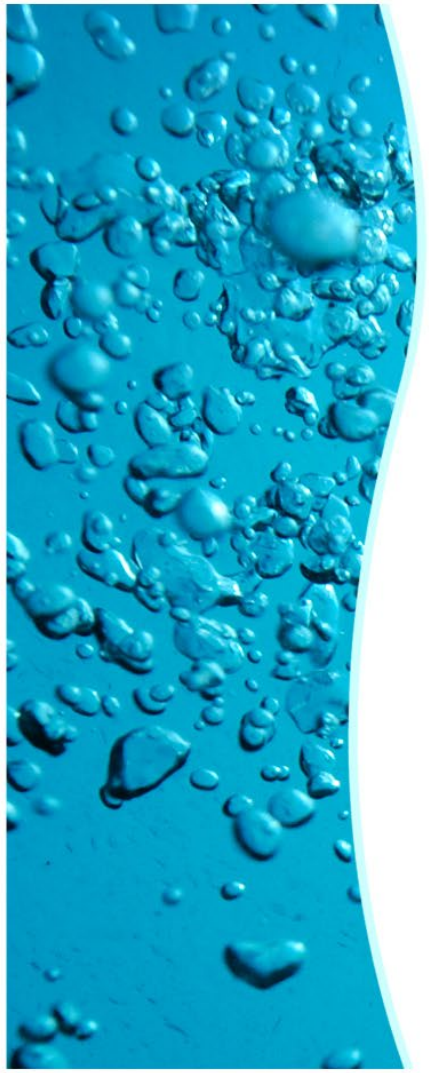
Why crystalloids will do the job in the operating room

- Non-expandable interstitial spaces
  - Only 7-8 L of 12L total interstitial fluid participates in distribution
    - Bone and organs surrounded by fibrous capsules not involved



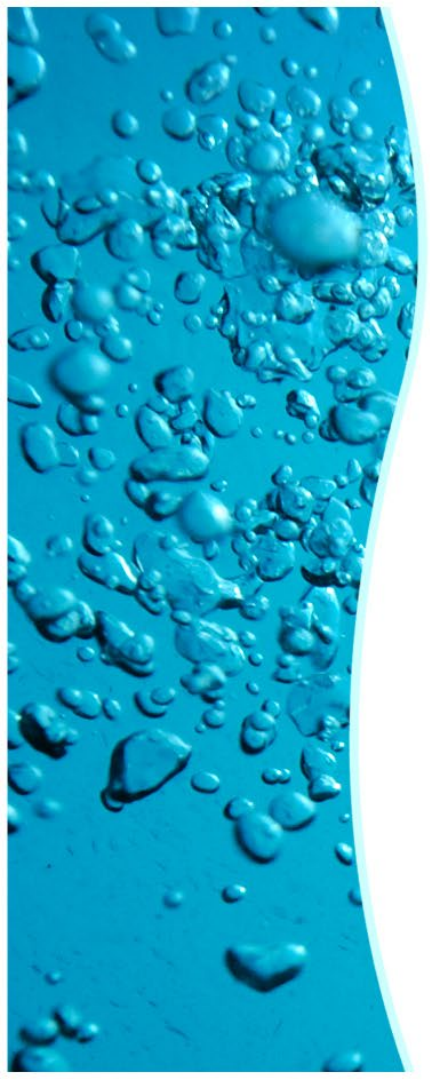
Why crystalloids will do the job in the operating room

- Slow elimination
  - Under general anesthesia elimination half life of crystalloids is prolonged 10x
    - Conscious person 15-30 minutes



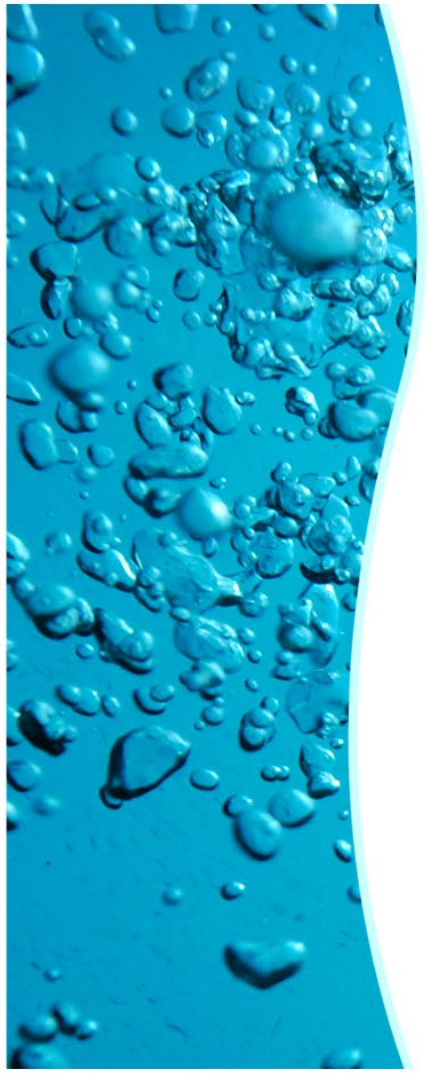
Why crystalloids will do the job in the operating room

- Capillary refill
  - During bleeding, fluid from the interstitial space shifts into the vasculature
    - 35% of lost volume within 30 minutes
    - Remainder over 24 hours
    - Blunted by anesthesia



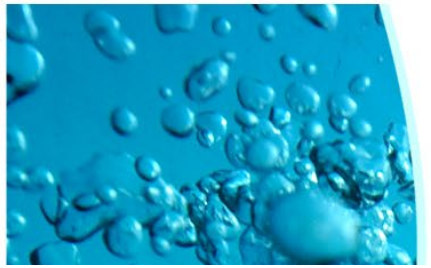
Why crystalloids will do the job in the operating room

- Caveat
  - Studies done on awake or anesthetized patients, not surgical patients
    - Inflammation from surgery will change results



Fluid Thinking with Professor Monty Mython

- Salt thinking not fluid thinking
  - Fluid excreted in hours
  - Salt excreted 24-48 hours
    - Activation of RAAS
- Post-operative care
  - Drinking in PACU, eating next morning
  - D/C IV fluids in PACU
  - If IV fluids needed use D5



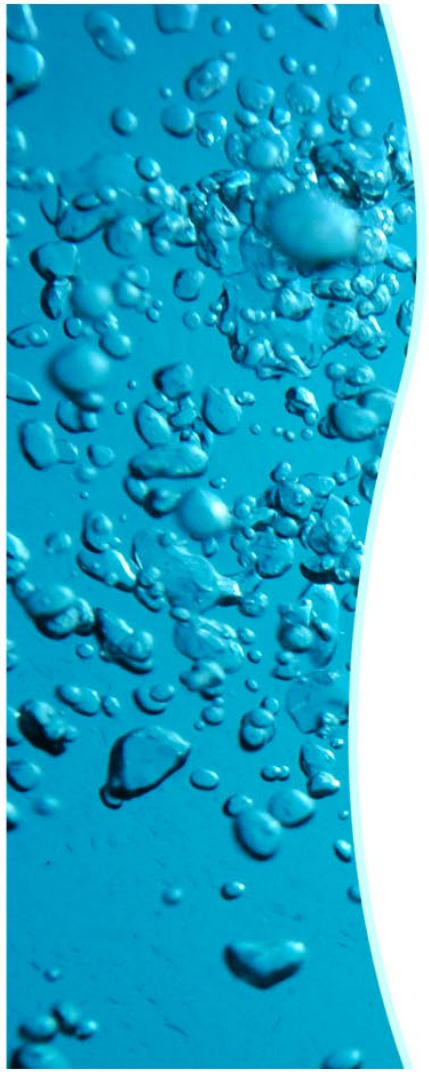
Fluid Thinking with Professor Monty Mython

		# of chips it would take to match the sodium content in 1 liter of listed IV fluid		# of orders of McDonalds medium fries it would take***
Solution	mEq Na per liter	Doritos (Nacho Cheese)*	Ruffles (Original)**	
0.2% NaCl	34	41	63	3
0.45% NaCl	77	93	142	6.5
LR	130	157	251	11.25
Plasmalyte	140	169	258	12
0.9% NaCl	154	186	283	13.3

*Based on 11 chips having 210 mg Na

**Based on 12 chips having 150 mg Na

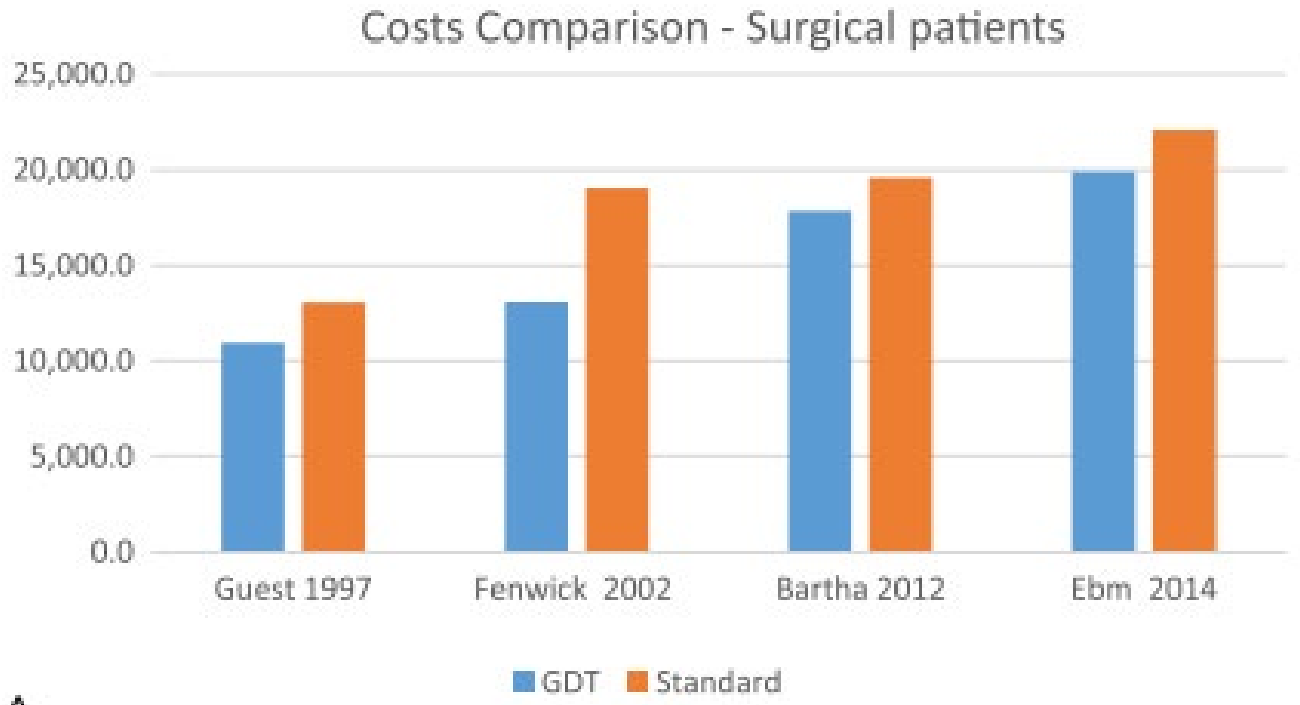
***Based on 1 order of medium fries having 266 mg Na



Fluid Thinking with Professor Monty Mython

- CHEERS
  - Carbohydrate loaded
  - Hydrated
  - Euvolemic
  - Eunatremic
  - Ready to start drinking, eating and ambulating

Cost effectiveness in goal directed therapy: are the dollars spent worth the value?



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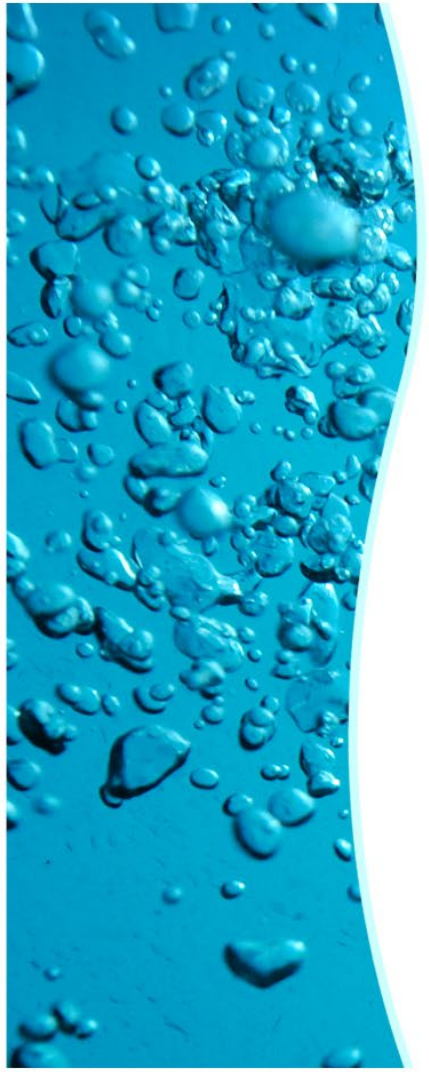


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

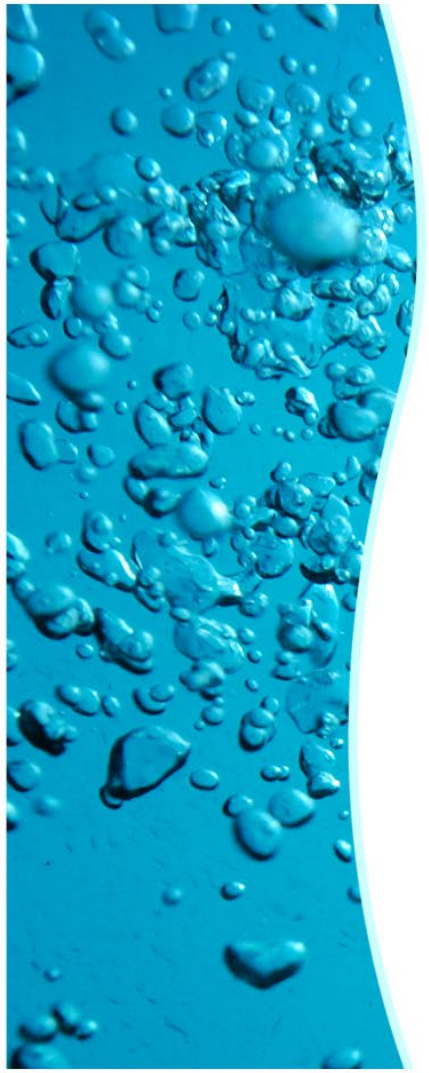
Balanced Crystalloids versus Saline in Noncritically Ill Adults

Wesley H. Self, M.D., M.P.H., Matthew W. Semler, M.D., Jonathan P. Wanderer, M.D., Li Wang, M.S., Daniel W. Byrne, M.S., Sean P. Collins, M.D., Corey M. Slovis, M.D., Christopher J. Lindsell, Ph.D., Jesse M. Ehrenfeld, M.D., M.P.H., Edward D. Siew, M.D., Andrew D. Shaw, M.B., Gordon R. Bernard, M.D., and Todd W. Rice, M.D., for the SALT-ED Investigators*

March 1, 2018

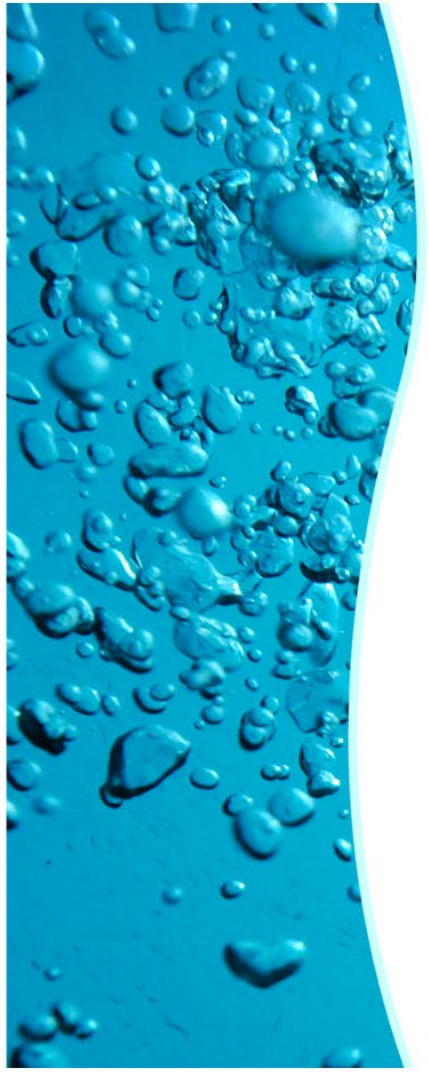
N Engl J Med 2018; 378:819-828

DOI: 10.1056/NEJMoa1711586



SALT-ED

- Design
  - Single center, pragmatic, multi-crossover trial
  - 13,347 patients over 16 months
  - Admitted from ED to non-ICU bed
  - Treated with Normal Saline vs balanced crystalloid (Lactated Ringers or Plasma-Lyte A)
- Results
  - No difference in length of hospital admission
  - Balanced crystalloids had a lower incidence of major adverse kidney events (4.7% vs 5.6%)
    - Death, new dialysis, persistent renal dysfunction (persistent serum creatinine >200% of baseline)



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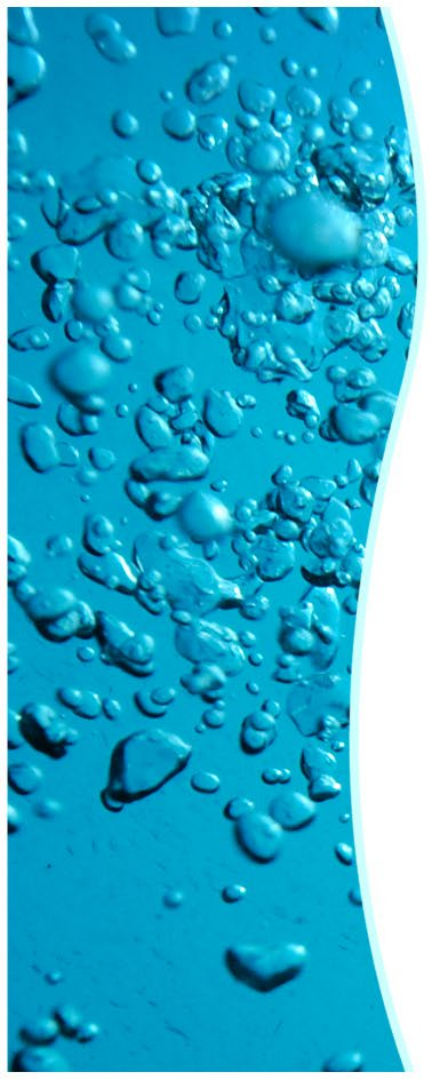
Balanced Crystalloids versus Saline in Critically Ill Adults

Matthew W. Semler, M.D., Wesley H. Self, M.D., M.P.H., Jonathan P. Wanderer, M.D., Jesse M. Ehrenfeld, M.D., M.P.H., Li Wang, M.S., Daniel W. Byrne, M.S., Joanna L. Stollings, Pharm.D., Avinash B. Kumar, M.D., Christopher G. Hughes, M.D., Antonio Hernandez, M.D., Oscar D. Guillamondegui, M.D., M.P.H., Addison K. May, M.D., Liza Weavind, M.B., B.Ch., Jonathan D. Casey, M.D., Edward D. Siew, M.D., Andrew D. Shaw, M.B., Gordon R. Bernard, M.D., and Todd W. Rice, M.D., for the SMART Investigators and the Pragmatic Critical Care Research Group*

March 1, 2018

N Engl J Med 2018; 378:829-839

DOI: 10.1056/NEJMoa1711584



SMART

- Design
  - 5 ICU at single center, pragmatic, cluster randomized, multi-crossover trial
  - 15,802 patients
  - Treated with Normal Saline vs balanced crystalloid (Lactated Ringers or Plasma-Lyte A)
- Results
  - Balanced balanced crystalloid lower incidence of
    - Major adverse kidney effects (14.3% vs 15.4%)
      - Death (10.3% vs 11.1%)
      - New dialysis (2.5% vs 2.9%)
      - Persistent renal dysfunction (6.4% vs 6.6%)

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Original Investigation | Emergency Medicine

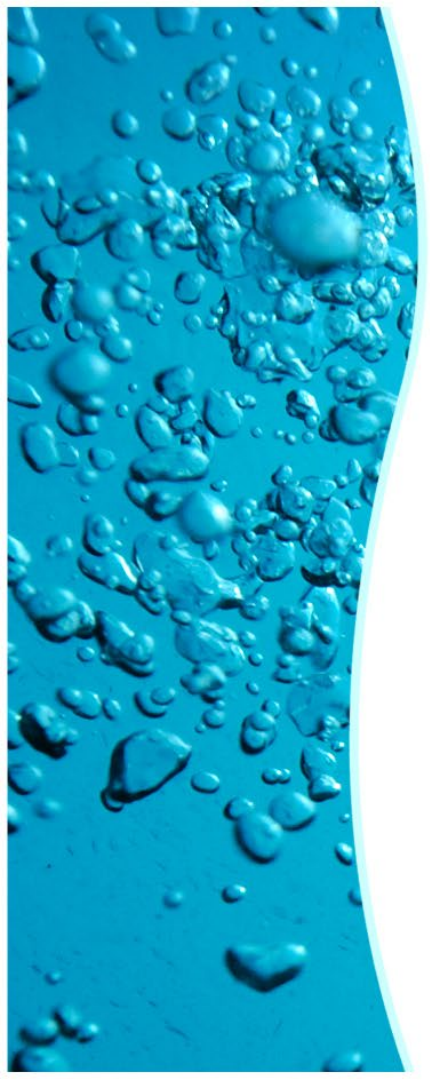
Clinical Effects of Balanced Crystalloids vs Saline in Adults With Diabetic Ketoacidosis

A Subgroup Analysis of Cluster Randomized Clinical Trials

Wesley H. Self, MD, MPH; Christopher S. Evans, MD, MPH; Cathy A. Jenkins, MS; Ryan M. Brown, MD; Jonathan D. Casey, MD, MSc; Sean P. Collins, MD, MSc; Taylor D. Coston, MD; Matthew Felbinger, PharmD; Lisa N. Flemmons, MSN, APRN, ACNP-BC; Susan M. Hellervik, MSN, ACNP-BC; Christopher J. Lindsell, PhD; Dandan Liu, PhD; Nicole S. McCoin, MD; Kevin D. Niswender, MD, PhD; Corey M. Slovis, MD; Joanna L. Stollings, PharmD; Li Wang, MS; Todd W. Rice, MD, MSc; Matthew W. Semler, MD, MSc; for the Pragmatic Critical Care Research Group

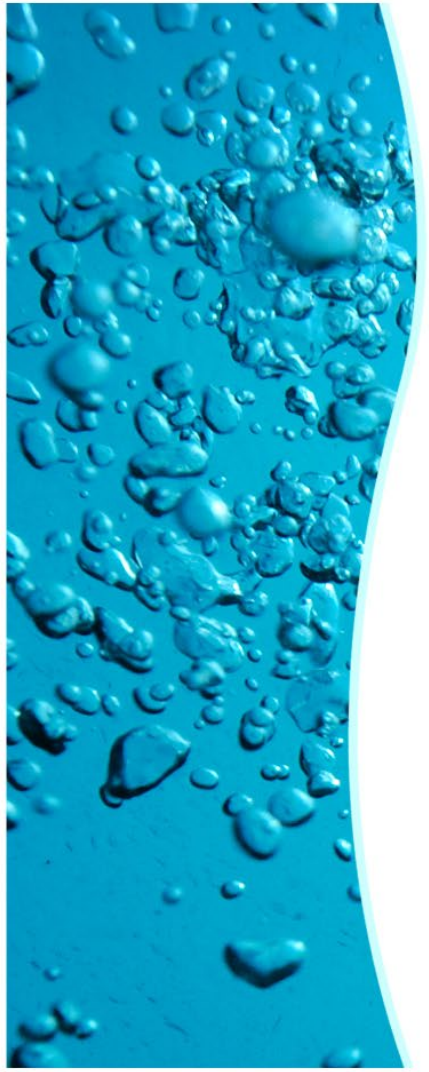
DKA

- Design
  - Sub-group analysis of patients in SMART and SALT-ED trial
    - 172 patients
    - DKA
      - Glucose > 250
      - Bicarb </= 18
      - Anion gap > 10



DKA

- Results
  - Balanced crystalloids
    - Shorter time to DKA resolution
      - 13 vs 16.9 hours
    - Shorter time to insulin discontinuation
      - 9.8 vs 13.4 hours



Normal saline *versus* a balanced crystalloid for goal-directed perioperative fluid therapy in major abdominal surgery: a double-blind randomised controlled study

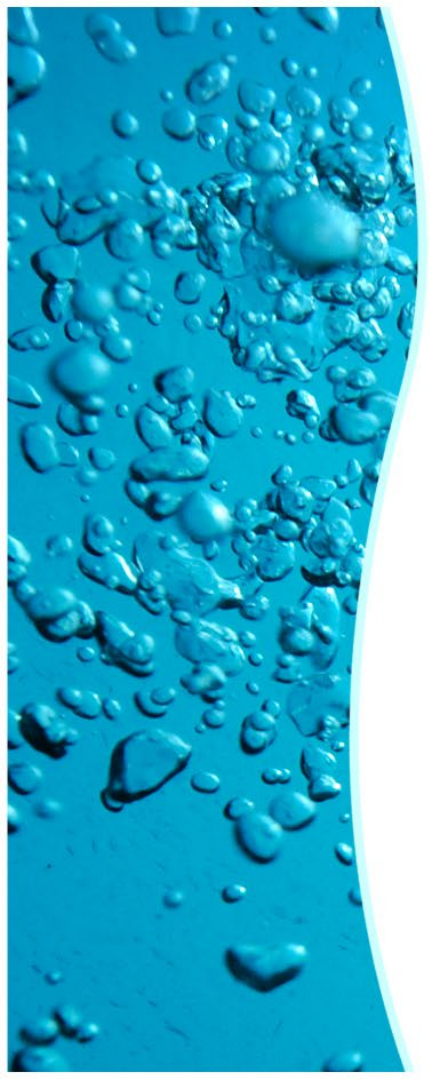
C.A. Pfortmueller, G.-C. Funk, C. Reiterer, A. Schrott, O. Zotti, B. Kabon, E. Fleischmann, G. Lindner

British Journal of Anaesthesia, 120 (2): 274–283 (2018)

doi: 10.1016/j.bja.2017.11.088

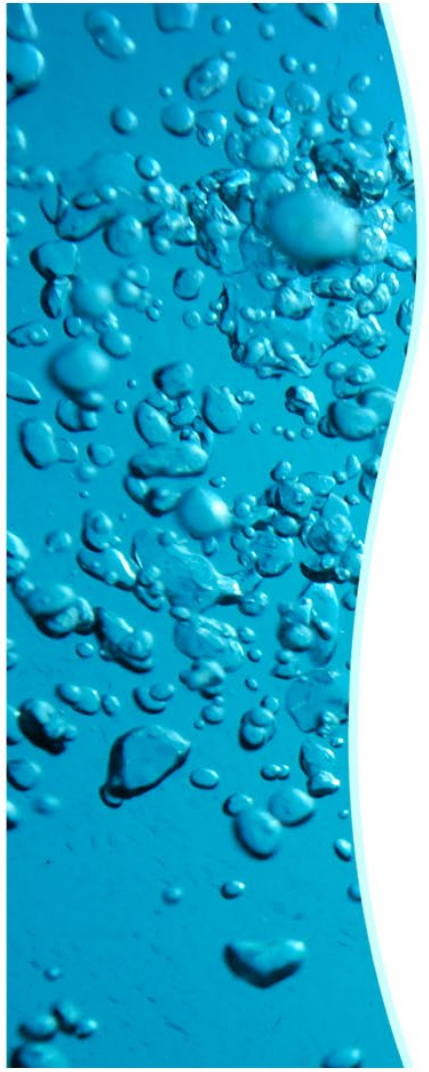
Advance Access Publication Date: 2 December 2017

Clinical Practice



Normal Saline vs Balanced Crystalloid

- Design
  - RCT GDT for fluid replacement during abdominal surgery
  - 240 patients planned (60 total 30 in each arm)
  - Outcomes vasopressor use, total vasopressor dose, fluid volume, and unexpected ICU admission
- Results
  - Terminated early for safety concerns
  - NS
    - Higher volume (average 3427 vs 3144 ml)
    - Needed more vasopressors (97% vs 67%)
    - Developed hyperchloremic metabolic acidosis
    - No difference in ICU admission

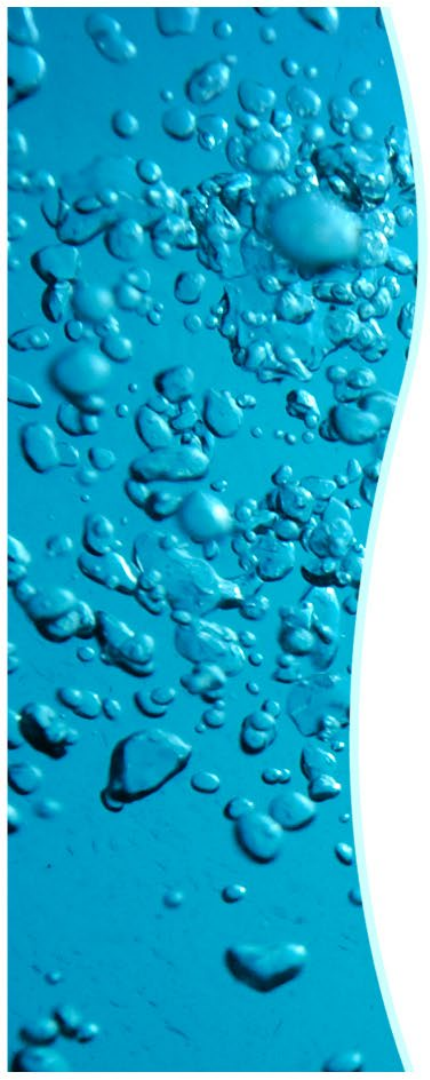


A Randomized, Double-Blind Comparison of Lactated Ringer's Solution and 0.9% NaCl During Renal Transplantation

Catherine M. N. O'Malley, FFARCSI*, Robert J. Frumento, MPH*, Mark A. Hardy, MD†, Alan I. Benvenisty, MD†, Tricia E. Brentjens, MD*, John S. Mercer, MD, and Elliott Bennett-Guerrero, MD*

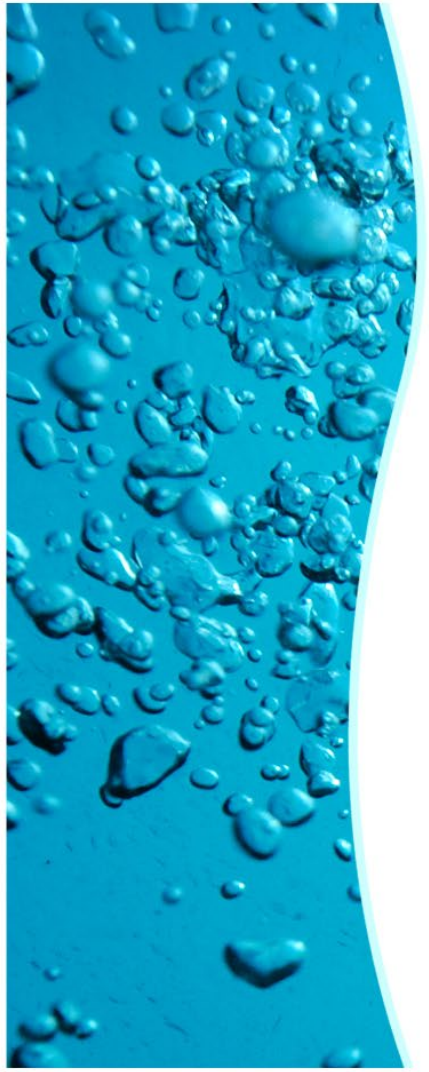
Departments of *Anesthesiology and †Surgery, Columbia University, College of Physicians & Surgeons, New York

Anesthesia & Analgesia. 100(5):1518-1524, MAY 2005
DOI: 10.1213/01.ANE.0000150939.28904.81, Issn Print: 0003-2999
Publication Date: 2005/05/01



LR vs NS Renal Transplant

- Design
  - RCT LR vs NS during kidney transplant
  - 51 patients (25 LR vs 26 NS)
- Results
  - Terminated early for safety concerns
  - Hyperkalemia (5 NS vs 0 LR)
  - Metabolic acidosis (8 NS vs 0 LR)

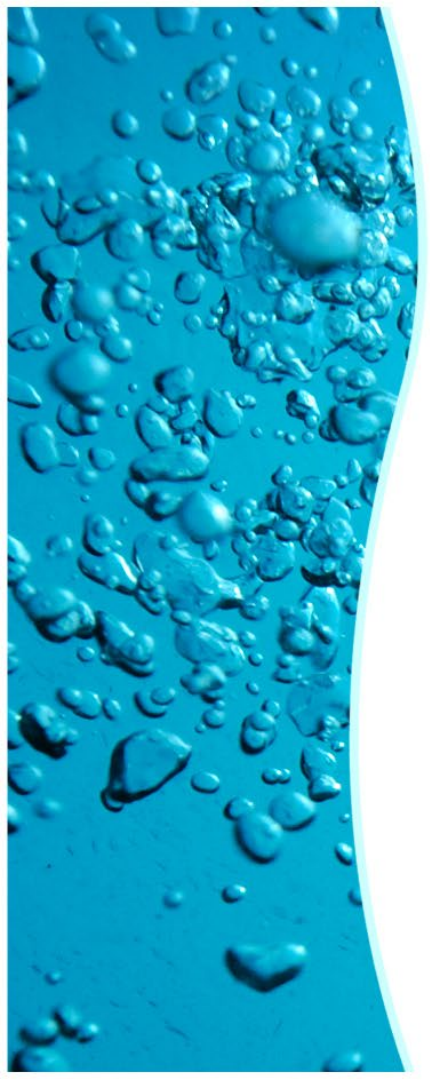


Effects of Normal Saline vs. Lactated Ringer's during Renal Transplantation

Mohammad Reza Khajavi, Farhad Etezadi, Reza Shariat Moharari, Farsad Imani, Ali Pasha Meysamie, Patricia Khashayar & Atabak Najafi

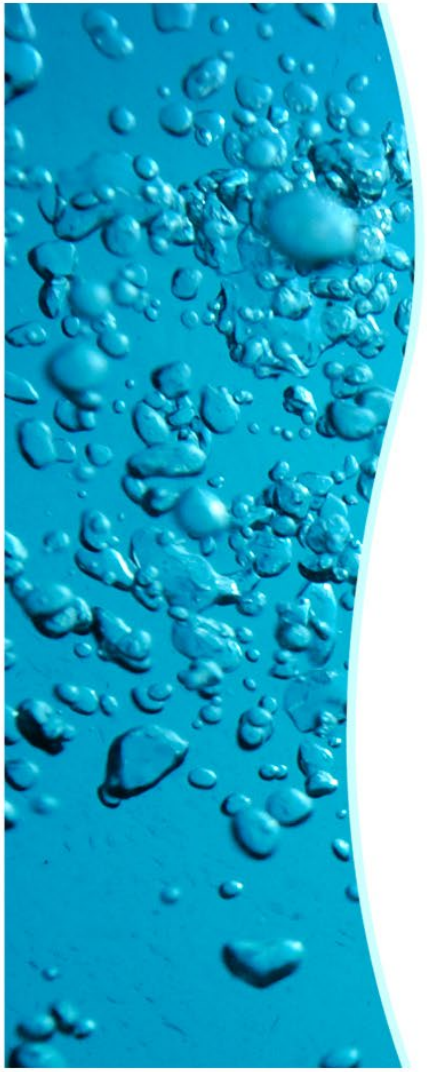
Renal Failure, 30:535–539, 2008

ISSN: 0886-022X print / 1525-6049 online
DOI: 10.1080/08860220802064770



LR vs NS Renal Transplant

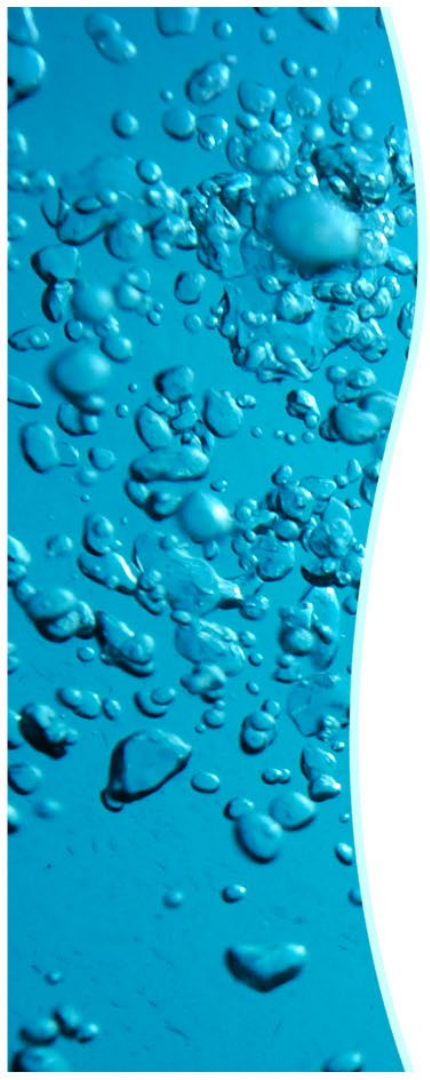
- Design
  - Double blind RCT NS vs LR during kidney transplant
  - 52 patients
- Results
  - NS
    - More acidosis(2 required bicarb infusion vs 0 LR)
    - Higher serum K (average 4.8 vs 4.03)
  - LR
    - High creatinine (2.2 vs 1.9)
    - Less urine output (3035 vs 3710)



Can Ringer's Lactate Be Used Safely with Blood Transfusions?

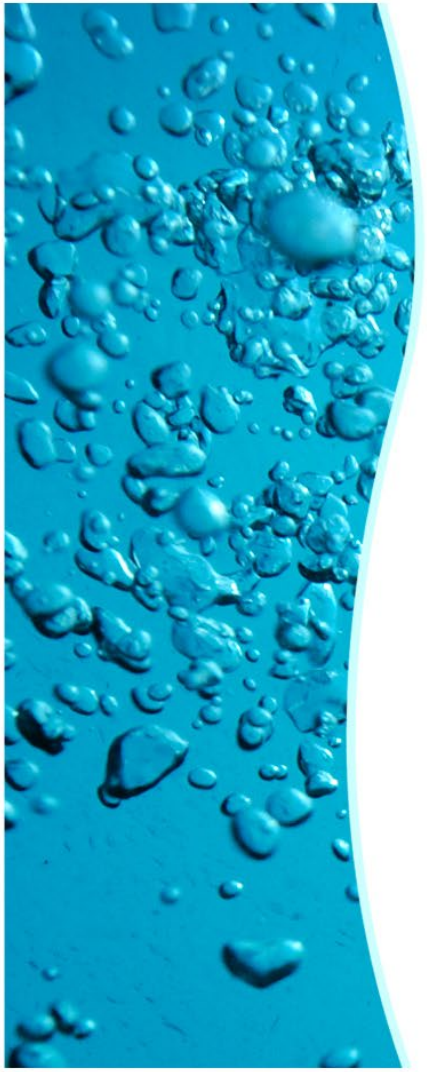
Manuel Lorenzo, MD, James W. Davis, MD, Steve Negin, MT, Krista Kaups, MD, Steven Parks, MD, Daniel Brubaker, DO, Alan Tyroch, MD, *Fresno, California*

THE AMERICAN JOURNAL OF SURGERY® VOLUME 175 APRIL 1998



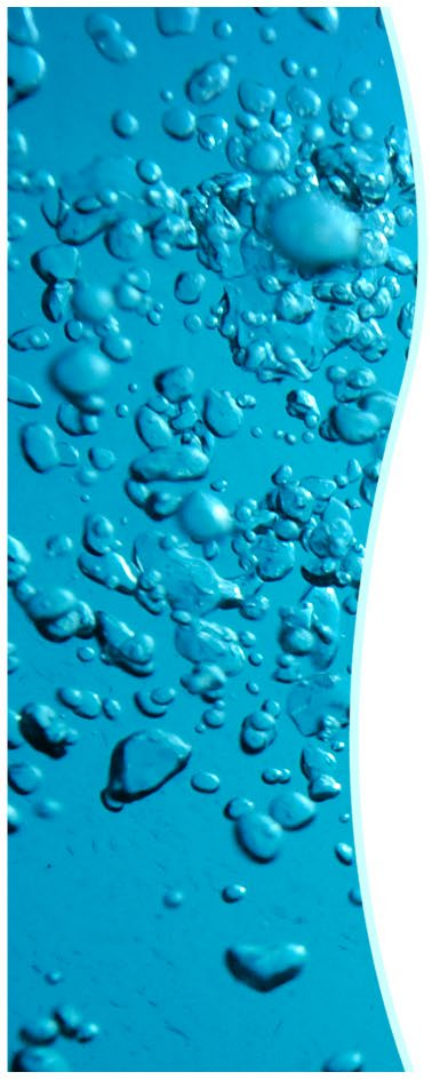
LR and blood transfusion

"This study demonstrates that LR does not cause increased coagulation vs NS at a blood crystalloid concentration of 1:1 during a blood transfusion at a rapid rate. Further, under these conditions an extraordinary amount of $CaCl_2$ (5 g/dl) would have to be added to LR before clinically significant clotting would occur at these infusion rates."



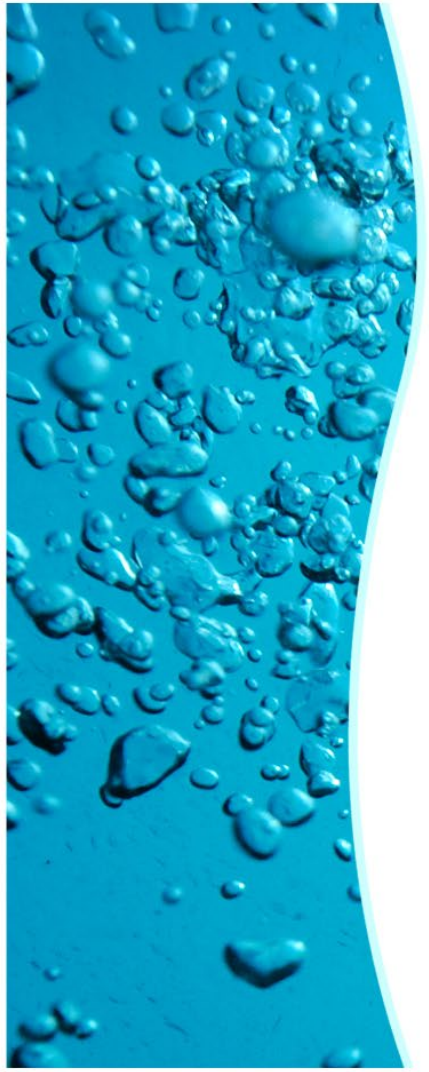
Ringer's lactate is compatible with saline-adenine-glucose-mannitol preserved packed red blood cells for rapid transfusion

Can J Anesth/J Can Anesth (2010) 57:1071–1077
DOI 10.1007/s12630-010-9396-z



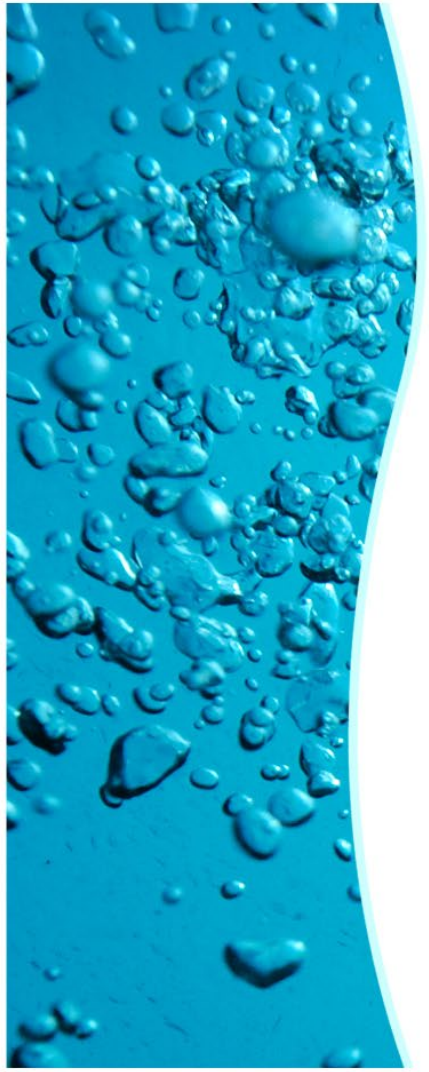
RL compatible with blood

"In summary, in the time frame inherent in the setting of rapid blood transfusion, such as for volume resuscitation in the operating room or emergency setting, there was no evidence that RL leads to clotting of RBC…blood should not be mixed with RL during slow transfusion."



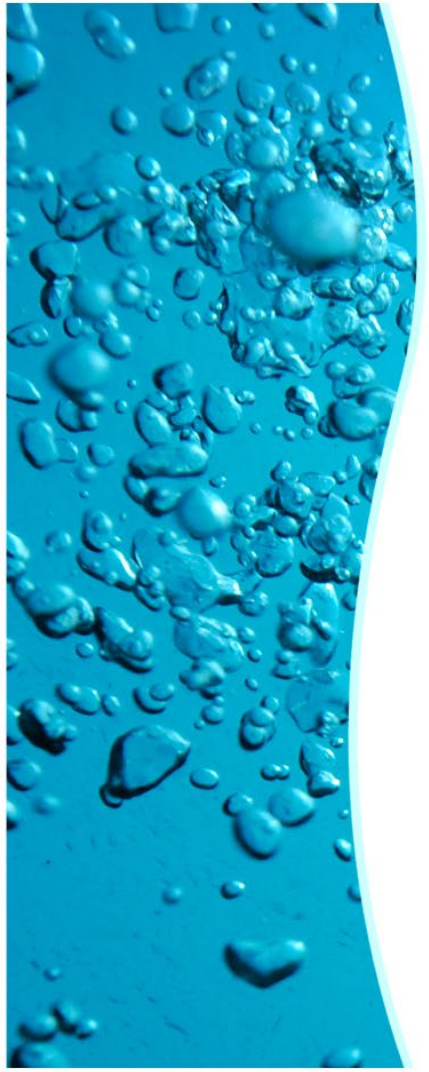
Conclusion

- Traditional fluid administration is associated with patient harm
- Intermediate risk patients undergoing intermediate risk surgery zero-balance or GDT is equivocal



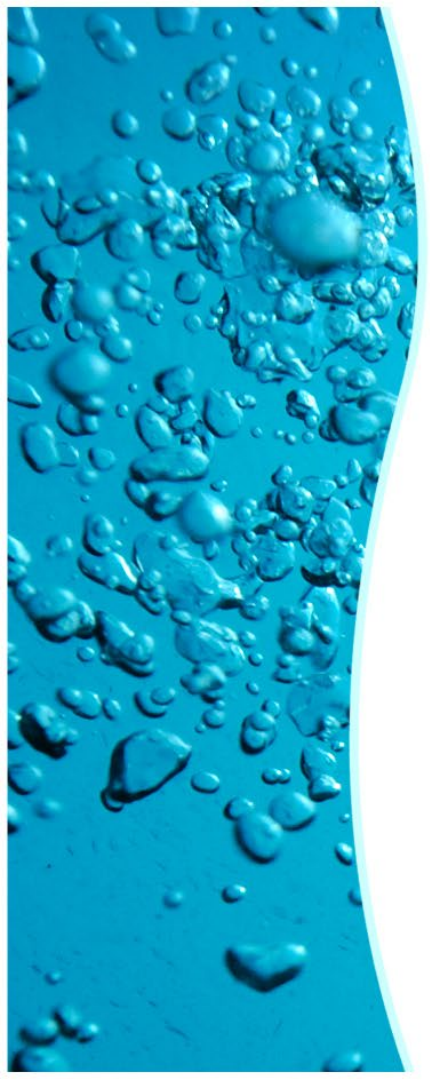
Conclusion

- High risk patients or high risk surgeries GDT is preferred
- Normal saline is associated with:
  - Acidosis
  - Hyperkalemia
  - Kidney injury



Conclusion

- Balanced crystalloids
  - Concerns about hyperkalemia are theoretical and unfounded



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