Diving Into Murky Waters

Perioperative Fluid Management in Pediatric Anesthesia

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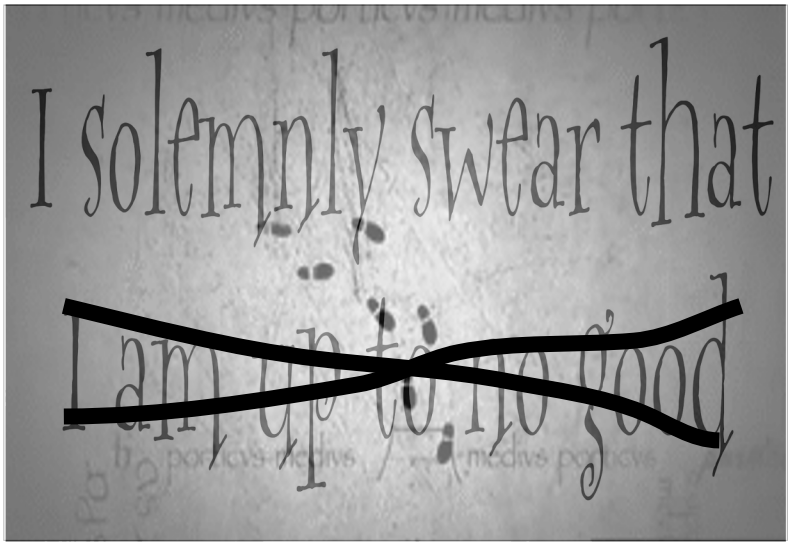

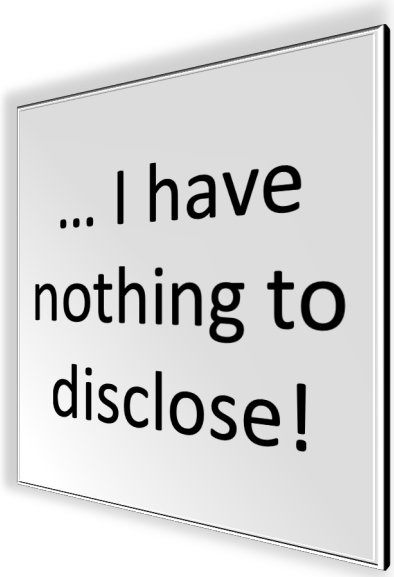

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Picture: Harry Potter

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Overview

- NPO Guidelines Updates
- AKI/Hydration Status
- 4-2-1 Rule
- Perioperative fluid management concepts
- The "ideal" pediatric perioperative fluid

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NPO Guidelines Updates

Picture: Star Wars
The Mandalorian

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NPO Guidelines Updates

Clear liquids → 2 hours
Breast milk → 4 hours
Solids → 6-8 hours

Reality

- Children strictly NPO up to 12 hrs
- > 80% strictly NPO for > 4 hrs

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Friedrich S. et al. "Nulla Per Os (NPO) guidelines: time to revisit?" Current Opinion Anaesthesiology 2020.

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European Society for Paediatric Anaesthesiology (ESPA)

European Society of Anaesthesiology (ESA)

L'Association des Anesthésistes-Réanimateurs Pédiatriques d'Expression Française (ADARPEF)

Association of Paediatric Anaesthetists of Great Britain and Ireland (APA)

Society for Paediatric Anaesthesia of New Zealand and Australia (SPANZA)

Canadian Pediatric Anesthesia Society (CPAS)

Clear liquid fasting times for elective general anesthesia and sedation can be reduced to 1 hour, unless clinically contraindicated.

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Thomas M, et al. "Consensus statement on clear fluids fasting for elective pediatric general anesthesia". Paediatr Anaesth. 2018
Friedrich et al. "Nulla Per Os (NPO) guidelines: time to revisit?" Curr Opin Anaesthesiol. 2020;33(6):740-745

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Beck C. et al Pediatric Anesthesia 2020

Received: 7 April 2020 | Revised: 2 June 2020 | Accepted: 5 June 2020
DOI: 10.1111/pan.13948
RESEARCH REPORT
Pediatric Anesthesia WILEY

Impact of clear fluid fasting on pulmonary aspiration in children undergoing general anesthesia: Results of the German prospective multicenter observational (NiKs) study

Christiane E. Beck[1] | Diana Rudolph[2] | Christoph Mahn[3] | Alexander Etspüler[4] |

- Multicenter study, 12093 children (10/2018-12/2019)
- Clear liquids up to 1 hour before anesthesia
- No increased incidence of regurgitation/pulmonary aspiration
  - Regurgitation (0.26%)
  - Suspected aspiration (0.08%)
  - Confirmed aspiration (0.03%)
- Risk groups: Age 1-3 years, Emergent procedures
- Postoperative respiratory distress rare after aspiration

Beck C et al. "Impact of clear fluid fasting on pulmonary aspiration in children undergoing general anesthesia: Results of the German prospective multicenter observational (NiKs) study". *Pediatric Anesthesia, 2020*

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Beck C. et al Pediatric Anesthesia 2020

Received: 7 April 2020 | Revised: 26 August 2020 | Accepted: 30 August 2020
DOI: 10.1111/pan.14029
RESEARCH REPORT
Pediatric Anesthesia WILEY

Ultrasound assessment of gastric emptying time after intake of clear fluids in children scheduled for general anesthesia—A prospective observational study

Christiane E. Beck[1] | Thurgkai Chandrakumar[1] | Robert Sümpelmann[1] |

" … gastric emptying time of children after intake up to 5 mL/kg clear fluids was < 1 hour in a clinical setting …"

- 24 children of ages 4-17 → "mimic clinical conditions"
- Variable amount/type of fluids (water/apple juice/orange juice)
  - 20 children < 5 ml/kg → gastric antral area back to baseline within 60 min
  - 4 children > 5 ml/kg → gastric antral area remains enlarged after 60 min
    - 2 with water, 2 with juice

Beck, C. et al. (2020). Ultrasound assessment of gastric emptying time after intake of clear fluids in children scheduled for general anesthesia—A prospective observational study. *Pediatric Anesthesia, 30*(12), 1384-1389.

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4-2-1 Rule

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Origins

- Introduced in the 1950ies
  - Developed for hypotonic **maintenance fluids**
  - **Not** designed for perioperative setting
  - Based on physiology knowledge of the time
    - perioperative ADH release/insulin resistance
  - "Normal child" in no acute distress

Holliday et al., "The maintenance need for water in parenteral fluid therapy", Pediatrics, 1957
Holliday et al., "Fluid therapy for children", facts, fashions and questions", Arch Dis Chil. 2007
Cote and Lerman, A Practice of Anesthesia for Infants and Children, 6th Edition

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Perioperative use of 4-2-1 Rule

- No accurate calculation of preop fluid deficits
  - Ignores physiologic fluid preservation
  - Overestimates preop fluid deficit
- Calculates running rate based on caloric requirements
  - Caloric requirements roughly correlates with BSA
  - BSA roughly correlates with weight
- Probably fine for healthy kids
  - May overestimate needs for kids at risk of fluid overload

Holliday et al., "The maintenance need for water in parenteral fluid therapy", Pediatrics, 1957
Holliday et al., "Fluid therapy for children", facts, fashions and questions", Arch Dis Chil. 2007
Cote and Lerman, A Practice of Anesthesia for Infants and Children, 6th Edition

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Picture: The Simpsons

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The "ideal" pediatric perioperative fluid

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The "ideal" pediatric perioperative fluid

- **Physiologic osmolality + Na^+**
  - prevents hyponatremia
- **Low Glucose concentration (1-2.5%)**
  - prevents hypoglycemia, hyperglycemia, gluconeogenesis
- **Buffered with metabolic anions**
  - prevents acid-base imbalance (hyperchloremic acidosis, etc.)

Suempelmann R et al., "Perioperative intravenous fluid therapy in children: guidelines from the Association of the Scientific Medical Societies in Germany", Pediatric Anesthesia 2017
Suempelmann, R. et al. "Perioperative fluid management in children: Can we sum it all up now?" Current Opinion in Anaesthesiology (2019)

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Europe

Pediatric Perioperative solutions

Polionique B66
E148 G1
ELO-PAED
RL-Glc

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Available fluids in the USA

Fluid	pH	Theoretical Osmolarity (mosm/L)	Actual **osmolality*** (mosm/kg H2O) / **at Glucose 4 mmol/L**	Na (mEq/L)	Cl (mEq/L)	K (mEq/L)	Ca (mEq/L)	Mg (mEq/L)	Buffer (mEq/L)	Glucose (mmol/L)
Human Plasma	**7.4**	**291**	**287**	**140**	**104**	**4.5**	**5**	**1.7**	**Bicarb. 25**	**2.8-5**
NaCl 0.9%	5.5	308	**290**	154	154	0	0	0	0	0
Lactated Ringers	6.5	274	258	130	109	4	3	0	Lactate 28	0
Ringer's Acetate	7.4	295	**290**	140	98	5	0	3	**Acetate 27** (Gluconate 23)	0
D5 NaCl 0.9%	4.0	586	**290**	154	154	0	0	0	0	278
D5 NaCl 0.45%	4.0	432	**147**	77	77	0	0	0	0	278
D10 NaCl 0.2%	4.0	623	**68**	34	34	0	0	0	0	555
D5 LR	5.0	552	**258**	130	109	4	3	0	Lactate 28	278

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*** Temperature independent, preferred in biological systems**

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"Perioperative pediatric solutions*"

Fluid	pH	Theoretical Osmolarity (mosm/L)	Actual **osmolality**** (mosm/kg H2O) / **at Glucose 4 mmol/L**	Na (mEq/L)	Cl (mEq/L)	K (mEq/L)	Ca (mEq/L)	Mg (mEq/L)	Buffer (mEq/L)	Glucose (mmol/L)
Human Plasma	**7.4**	**291**	**287**	**140**	**104**	**4.5**	**5**	**1.7**	**Bicarb. 25**	**2.8-5**
E148 G1 Paed (BS-G1)	6.0	352	**275**	140	118	4	2	2	Acetate 30	55.5
Polionique B66	?	309	**240**	120	108.3	4.2	2.8	0	Lactate 20.7	50.5
ELO-PAED	?	356	**278**	142	126	4	1	1	Acetate 24	55.5
RL-Glc	?	**331.5**	**257**	130	109	4	3	0	Lactate 28	55.5

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*** Not FDA approved**
**** Temperature independent, preferred in biological systems**

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Why is the ideal pediatric perioperative fluid isotonic?

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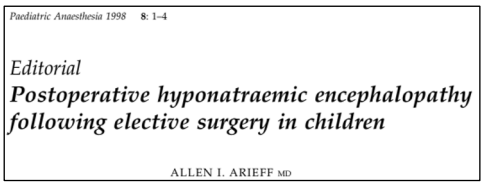
Hyponatremia


Paediatric Anaesthesia 1998 8: 1–4

Editorial

Postoperative hyponatraemic encephalopathy following elective surgery in children

ALLEN I. ARIEFF MD

- Arieff (1998):
  - **Up to 15000 deaths** due to perioperative hyponatremia per year in the US (women + children at risk)
  - **Extrapolated** numbers based on study results
- Perioperative use of hypotonic fluids
  - … still happens in peds
  - Maintenance therapy from the floor → continued in OR

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Ayus, J. et al. "Brain damage and postoperative hyponatremia: The role of gender" Neurology. 1996
Arieff, A. et al. "Postoperative hyponatraemic encephalopathy following elective surgery in children". *Pediatric Anesthesia, 1998*

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My own M&M case report

Female, 3.6 kg
Ex 22-week
(now 42w5d)

NICU IVF: D10/0.2% NaCl
23.2 ml/hr (6.4 ml/kg/hr!!)

Stopped IVF
Ringer Acetate
boluses

Exploratory laparotomy + Ileostomy takedown

New onset Hyponatremia
139 → 129 mmol/L

No obvious sequelae

	0504	1524	1626	1750	1838	2025	2353	0600
CHEMISTRY								
Sodium	139	129	130	130	130	131	134	141

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Pediatric Hyponatremia

- Up to 30% of pediatric electrolyte abnormality
- **Elevated ADH → hyponatremia risk**
  - **Perioperative/postoperative stress, Pain, Nausea**
  - Critical illness, Hypovolemia, Resp. failure, CNS disorders, …
- **Hypotonic IVF → Iatrogenic Hyponatremic Encephalopathy**
  - Brain edema, Seizures, Morbidity, Mortality, …
  - Worse in peds → less "swelling room"
  - May happen after minor procedures!!

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Feld, L, et al. "Clinical Practice Guideline: Maintenance Intravenous Fluids in Children", Pediatrics Dec 2018

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Rapidly developing iatrogenic hyponatremia in a child following tonsillectomy

Umit Taskin, MD; Omer Binay, MD; Cigdem Binay, MD; Ozgur Yigit, MD

5 year old
Female
No weight
Tonsillectomy

D5/0.18% NaCl
500 ml
During anesthesia

D5/0.18% NaCl
1000 ml 5 hours after T+A
Pain with swallowing

D5/0.18% NaCl
500 ml 6 hours after T+A
Due to "PONV" (!!)

Tonic Clonic Seizure
Fixed + Dilated Pupils

Hyponatremia
139 → 119 mmol/L

NaCl 3% infusion
Improved neuro status
NA 135 mmol/L

No long term sequelae

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Taskin U, et al. Rapidly Developing Iatrogenic Hyponatremia in a Child following Tonsillectomy. Ear, Nose & Throat Journal. 2012;91(11):486-487.

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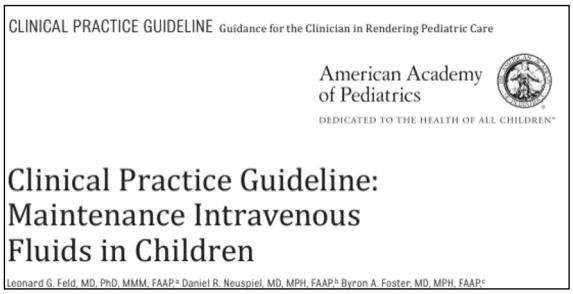

"… Patients 28 days to 18 years of age requiring maintenance IVFs should receive isotonic solutions with appropriate KCl and dextrose because they significantly decrease the risk of developing hyponatremia"

Evidence quality: A
Recommendation strength: strong

1A

Includes:
Patients > 28 day, surgical, postop, ICU, Med/Surg floor

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Feld, L, et al. "Clinical Practice Guideline: Maintenance Intravenous Fluids in Children", Pediatrics Dec 2018

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Exemptions

- Significant free water loss
  - Renal concentrating defects (nephrogenic DI)
  - Voluminous diarrhea/Severe burns
- Severe hypernatremia
- Neonatal ICU + patients < 28 days
  - corrected < 44 weeks post conception
- Neurosurgical disorders
- Severe renal, cardiac or liver disease
- Cancer/Hematology

Missing evidence?

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Feld, L, et al. "Clinical Practice Guideline: Maintenance Intravenous Fluids in Children", Pediatrics Dec 2018,

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Why is the ideal pediatric perioperative fluid low in glucose?

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Perioperative stress

Insulin resistance
Administered glucose does not get absorbed

Glucagon/Epinephrine/Cortisol
Catabolism → Gluconeogenesis
Rebound hyperglycemia

Perioperative Hyperglycemia

"Prevention over Correction"
Insulin infusion over bolus

Correction:
Glucose >250 mg/dl
Diabetic/transplant surgery

Datta et al., "Glucose for Children during Surgery: Pros, Cons, and Protocols: A Postgraduate Educational Review." *Anesth Essays Res.* 2017
Picture: Winnie the Pooh

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Hyperglycemia "side effects"

- Intraventricular hemorrhage
- Retinopathy of prematurity
- Necrotizing enterocolitis
- Bronchopulmonary dysplasia
- Osmotic diuresis
- Renal injury
- Impaired immunity
- Delayed wound healing
- Neuronal lactic acidosis

Datta et al., "Glucose for Children during Surgery: Pros, Cons, and Protocols: A Postgraduate Educational Review." *Anesth Essays Res.* 2017
Picture: Winnie the Pooh

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Preemie/Neonate Glucose metabolism

- Require glucose up to 300 mg/kg/hr
  - Brain function/development
- Gluconeogenesis → prevents hypoglycemia
  - Fat and protein catabolism
  - Rebound hyperglycemia
- **Adequate** glucose substitution
  - prevent catabolic response/rebound

Datta et al., "Glucose for Children during Surgery: Pros, Cons, and Protocols: A Postgraduate Educational Review." *Anesth Essays Res.* 2017
Datta et al., "Dextrose-containing intraoperative fluid in neonates: a randomized controlled trial", Pediatric Anesthesia, 2016

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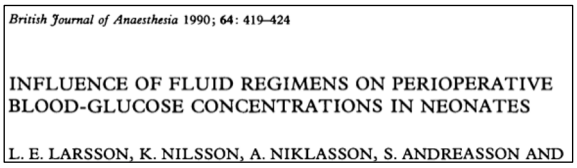
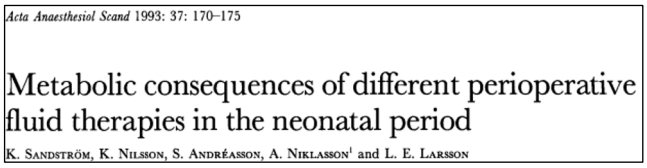

British Journal of Anaesthesia 1990; 64: 419–424

INFLUENCE OF FLUID REGIMENS ON PERIOPERATIVE BLOOD-GLUCOSE CONCENTRATIONS IN NEONATES

L. E. LARSSON, K. NILSSON, A. NIKLASSON, S. ANDREASSON AND


Acta Anaesthesiol Scand 1993: 37: 170–175

Metabolic consequences of different perioperative fluid therapies in the neonatal period

K. Sandström, K. Nilsson, S. Andréasson, A. Niklasson[1] and L. E. Larsson

- Prospective studies in neonates
- Dextrose 10% versus Ringer's Acetate (RA)
  - 4 ml/kg/hour + RA boluses
  - Hyperglycemia both groups → even 8 hours postop
  - Hypoglycemia only during first hour of anesthetic
- Surgical stress releases epinephrine and glucagon
  - Neonates metabolize fat tissue for gluconeogenesis

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1. Larsson LE et al. Influence of fluid regimens on perioperative blood-glucose concentrations in neonates. Br J Anaesth. 1990;64:419–24
2. Sandström K, et al. Metabolic consequences of different perioperative fluid therapies in the neonatal period. Acta Anaesthesiol Scand. 1993;37:170–5. [PubMed: 8447207

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Pediatric Anesthesia

Pediatric Anesthesia ISSN 1155-5645

ORIGINAL ARTICLE

A novel isotonic balanced electrolyte solution with 1% glucose for intraoperative fluid therapy in neonates: results of a prospective multicentre observational postauthorisation safety study (PASS)

Robert Sümpelmann[1], Thomas Mader[2], Nils Dennhardt[1], Lars Witt[1], Christoph Eich[3] &

- 66 neonates
- Weight: 0.65-4.6 kg
- Variable procedures
- Fluids → balanced, isotonic, 1% Glucose
- Mean running rate → 10 ml/kg/hr
  - **No incidence of hypoglycemia/hyperglycemia**
  - No hemodynamic issues/fluid overload
- Neonates need intraoperative monitoring of labs
  - especially in long/invasive procedures

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Suempelmann R., et al. A novel isotonic balanced electrolyte solution with 1% glucose for intraoperative fluid therapy in neonates: Results of a prospective multicentre observational Postauthorisation Safety Study (PASS) Paediatr Anaesth. 2011

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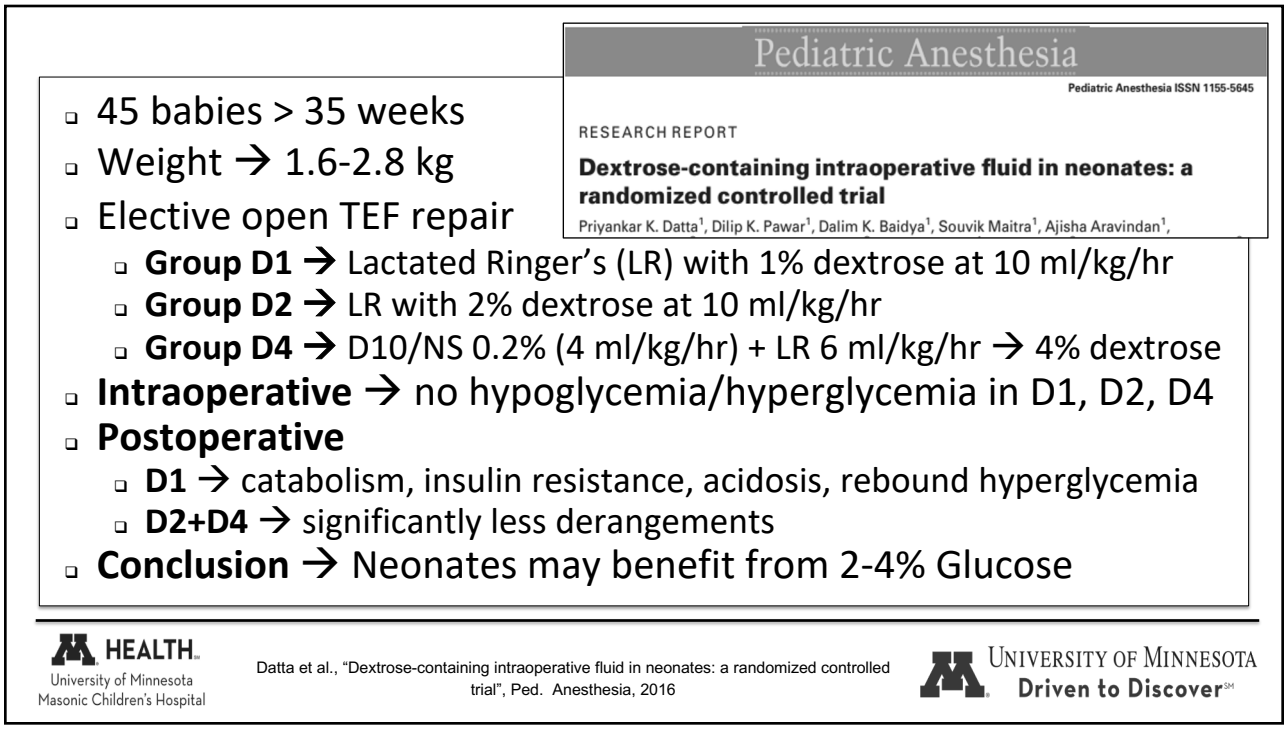
Pediatric Anesthesia
Pediatric Anesthesia ISSN 1155-5645
RESEARCH REPORT
Dextrose-containing intraoperative fluid in neonates: a randomized controlled trial
Priyankar K. Datta[1], Dilip K. Pawar[1], Dalim K. Baidya[1], Souvik Maitra[1], Ajisha Aravindan[1],
45 babies > 35 weeks
Weight → 1.6-2.8 kg
Elective open TEF repair
Group D1 → Lactated Ringer's (LR) with 1% dextrose at 10 ml/kg/hr
Group D2 → LR with 2% dextrose at 10 ml/kg/hr
Group D4 → D10/NS 0.2% (4 ml/kg/hr) + LR 6 ml/kg/hr → 4% dextrose
Intraoperative → no hypoglycemia/hyperglycemia in D1, D2, D4
Postoperative
D1 → catabolism, insulin resistance, acidosis, rebound hyperglycemia
D2+D4 → significantly less derangements
Conclusion → Neonates may benefit from 2-4% Glucose
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Datta et al., "Dextrose-containing intraoperative fluid in neonates: a randomized controlled trial", Ped. Anesthesia, 2016
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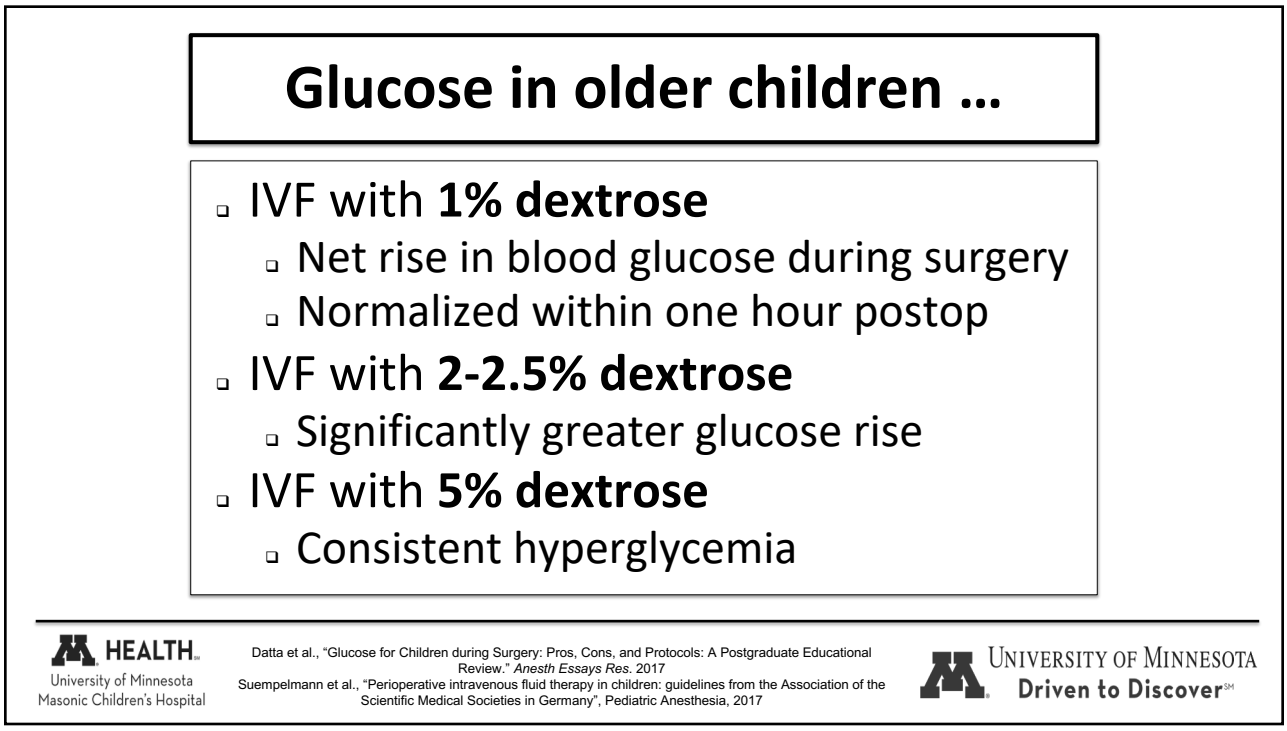
Glucose in older children …
IVF with 1% dextrose
Net rise in blood glucose during surgery
Normalized within one hour postop
IVF with 2-2.5% dextrose
Significantly greater glucose rise
IVF with 5% dextrose
Consistent hyperglycemia
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Datta et al., "Glucose for Children during Surgery: Pros, Cons, and Protocols: A Postgraduate Educational Review." Anesth Essays Res. 2017
Suempelmann et al., "Perioperative intravenous fluid therapy in children: guidelines from the Association of the Scientific Medical Societies in Germany", Pediatric Anesthesia, 2017
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Why is the ideal pediatric perioperative fluid balanced/buffered?

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Limited Evidence …

- Systematic, well powered studies are scarce …
- **Stenson (2018)**[1] → Retrospective analysis
  - **Hyperchloremia** → independently associated with poor outcomes among children with septic shock
- **Emrath (2017)**[2] → Retrospective analysis
  - **Exclusive** use of balanced fluids versus **exclusive** use of unbalanced fluid in pediatric severe sepsis for first 72 hours
  - Improved survival, decreased AKI, and shorter duration of vasoactive infusions with balanced fluids

1) Stenson EK, et al. Hyperchloremia Is Associated With Complicated Course and Mortality in Pediatric Patients With Septic Shock. Pediatr Crit Care Med. 2018 Feb;19(2):155-160.
2) Emrath, E et al. Resuscitation With Balanced Fluids Is Associated With Improved Survival in Pediatric Severe Sepsis*, Critical Care Medicine: July 2017 - Volume 45 - Issue 7 - p 1177-1183

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NaCl 0.9%

- Decreased renal blood flow[1)2)]
- Hyperchloremic acidosis
  - Postop increased Acute kidney injury (AKI)[1)2)]
  - Chloride-Restriction → Less AKI in ICU patients [3)]
  - Liberal chloride use → more AKI after liver Tx [4)]
  - Increased risk for hyperkalemia, coagulopathy

1) O. Goren et al., "Perioperative acute kidney injury", British Journal of Anaesthesia, 115 (S2): (2015)
2) X. Ding et al., "Intravenous fluids and acute kidney Injury", Blood Purif 2017; 43: 163-172
3) N. Yunos et al., "Association between a chloride-liberal vs chloride-restrictive intravenous fluid administration strategy and kidney injury in critically ill adults". JAMA 2012; 308: 1566–72)
4) A. Nadeem et al., "Chloride-liberal fluids are associated with acute kidney injury after liver transplantation." Crit Care 2014; 18: 625

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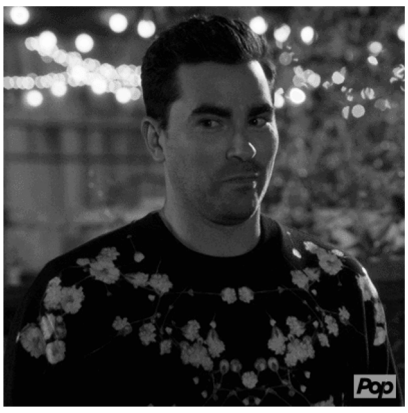
AKI Hydration Status



Picture: Schitt's Creek

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Perioperative AKI - Causes

- **Prerenal Causes** (up to 70%) → poor kidney perfusion
  - Hypovolemia + Hypervolemia
  - **Invasive pro** iac surgery)
  - Loss of cardi s)
- **Renal causes** (
  - HUS, inflamm ns, pyelonephriti
- **Postrenal caus**
  - Tumor lysis s is
  - Kidney stones, congenital malformations in ureter/bladder/urethra

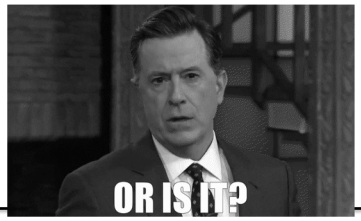
Fluid Overload Euvolemia

Fluid overload

- Healthy children tolerate liberal fluid strategies
- Preemies/Neonates/Sick children are at risk
  - **Unchecked fluid administration**
  - **"Maintenance rate" + ADH surge**
  - Flushing medications in preemies/neonates
    - Flush volume exceeds cardiac stroke volume
    - Creates strain on heart
- Procedures with "uncharted" fluid administration
  - Heart catheterization, IR procedures, etc.

Pediatric euvolemia … difficult to assess

- Blood pressure
  - Reflection of autonomous nervous system
- CVP + IVC ultrasound → unreliable in peds
- Pulse pressure variation → less established in children
- NIRS/O2 extraction may act as proxy
  - in absence of heart dysfunction/anemia
- **There is always urine output …**



Perioperative urine output[1)2)]

- Perioperative ADH release
  - Decreased urine output
  - Increased fluid retention
- UOP does not correlate with hydration status

Additional fluids do not significantly increase UOP under GA[3),4)]

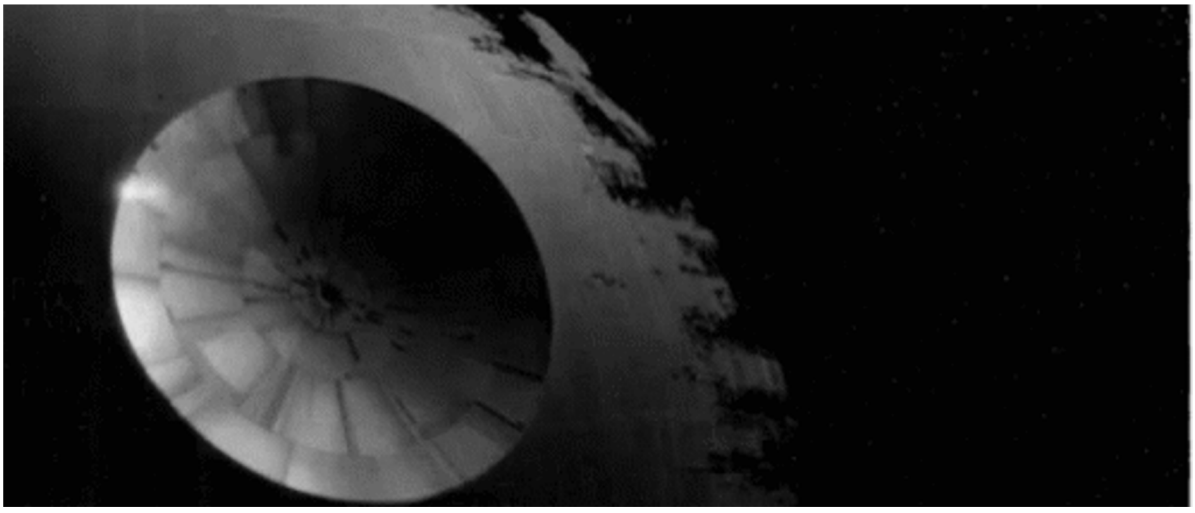
1) O. Goren et al., "Perioperative acute kidney injury", British Journal of Anaesthesia, 115 (S2): (2015)
2) X. Ding et al., "Intravenous fluids and acute kidney Injury", Blood Purif 2017; 43: 163-172
3) I Matot et al, "Fluid management during video-assisted thoracoscopic surgery for lung resection: a randomized, controlled trial of effects on urinary output and postoperative renal function." J Thorac Cardiovasc Surg 2013; 146: 461–6
4) I. Matot et al. "Effect of the volume of fluids administered on intraoperative oliguria in laparoscopic bariatric surgery: a randomized controlled trial. Arch Surg 2012; 147: 228–34

Perioperative Urine Output + AKI [1)2)]

- Low UOP (under GA) does **NOT** correlate with AKI
- Fluid restrictive vs. liberal fluid approach
  - Equal AKI risk
  - Higher Risk of AKI with fluid overload
- Diuretics/Mannitol do not prevent AKI
  - May increase AKI risk → pre-Renal Injury

Diuretics are meant for hypervolemia, not for low UOP

1) O. Goren et al., "Perioperative acute kidney injury", British Journal of Anaesthesia, 115 (S2): (2015)
2) X. Ding et al., "Intravenous fluids and acute kidney Injury", Blood Purif 2017; 43: 163-172
3) I Matot et al, "Fluid management during video-assisted thoracoscopic surgery for lung resection: a randomized, controlled trial of effects on urinary output and postoperative renal function." J Thorac Cardiovasc Surg 2013; 146: 461–6
4) I. Matot et al. "Effect of the volume of fluids administered on intraoperative oliguria in laparoscopic bariatric surgery: a randomized controlled trial. Arch Surg 2012; 147: 228–34



Picture: Star Wars

Perioperative fluid management concepts

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"Standard" case (UMN)

(Relatively) Short case
Limited fluid shift/blood loss
"Normal" NPO time
No major comorbidities

Age 48 months +
Total perioperative volume
10-20 ml/kg
Isotonic + balanced fluids

Age 12-47 months
Total perioperative volume
20-30 ml/kg
Isotonic + balanced fluids

Glucose rarely required

Cote/Lerman 6th edition, Fluid management
Murat et al., "Perioperative fluid therapy in pediatrics", Pediatric Anesthesia 2008, 18m, 363-370

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Complex Cases (UMN)

Patients < 10 kg or < 12 months

LR with 2% Glucose

10 ml/kg/hr over first hour or 10 ml/kg bolus over 30 minutes

Slow down based on fluids and glucose
Start slower, if arrives with IVF

Lactated Ringer's/Ringer's Acetate for additional fluid boluses

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Complex Cases (UMN)

Patients > 10 kg or > 12 months

Lactated Ringer's/Ringer's Acetate
Goal directed therapy

Glucose only with hypoglycemia risk
Insulinomas
Metabolic Disease
Liver transplant
Very long cases

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Complex Cases (UMN)

Patients arriving with IVF (5-10% Glucose)

Switch to Lactated Ringer's + 2% Glucose
or
Decrease running rate by 50% (or more)

Patients arriving with TPN
Continue TPN at 50-100% rate from floor
Check Glucose content

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Cote/Lerman 6th edition, Fluid management
Murat et al., "Perioperative fluid therapy in pediatrics", Pediatric Anethesia 2008, 18m, 363-370

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"Standard" postop strategy

- Switch back to preoperative fluids (5-10% Glucose)
  - Acceptable to maintain normoglycemia
- Avoid hypotonic fluids
  - ADH remains elevated up to 12 hours
  - Consider decreased running rate (2/1/0.5)
- **Correct hypovolemia with isotonic, balanced fluids**
- **Alternative** → enteral feeding (if possible)
  - Less need for glucose containing fluids

M HEALTH University of Minnesota Masonic Children's Hospital

Suempelmann et al., "Perioperative intravenous fluid therapy in children: guidelines from the Association of the Scientific Medical Societies in Germany", Pediatric Anesthesia, 2017
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Murat et al., "Perioperative fluid therapy in pediatrics", Pediatric Anesthesia 2008, 18m, 363-370

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Fluid therapy summary … in one slide

Low aspiration risk with Clear liquids up to one hour before induction

Isotonic + balanced IVF for fluid resuscitation

Correct fluid deficits before induction in complex cases

Avoid glucose containing IVF for fluid resuscitation

Colloids have minimal known benefits
Consider as 2nd line

Background infusion
(preemies/neonates/infants)

Isotonic (hyponatremia)

Glucose 1-2.5% (glucose overload + rebound hyperglycemia

Balanced (Acidosis, AKI)

Suempelmann et al., "Perioperative intravenous fluid therapy in children: guidelines from the Association of the Scientific Medical Societies in Germany", Pediatric Anesthesia, 2017
Suempelmann, R. et al. "Perioperative fluid management in children: Can we sum it all up now?" Current Opinion in Anaesthesiology (2019)

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jguenthe@umn.edu

Picture: Gladiator

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