Wilhelmina Children's Hospital

Perioperative fluid management in children

Gersten Jonker, paediatric anaesthetist

BAPA-SKA Refresher Course
January 2016, Leuven

Disclosure

DISCLAIMER

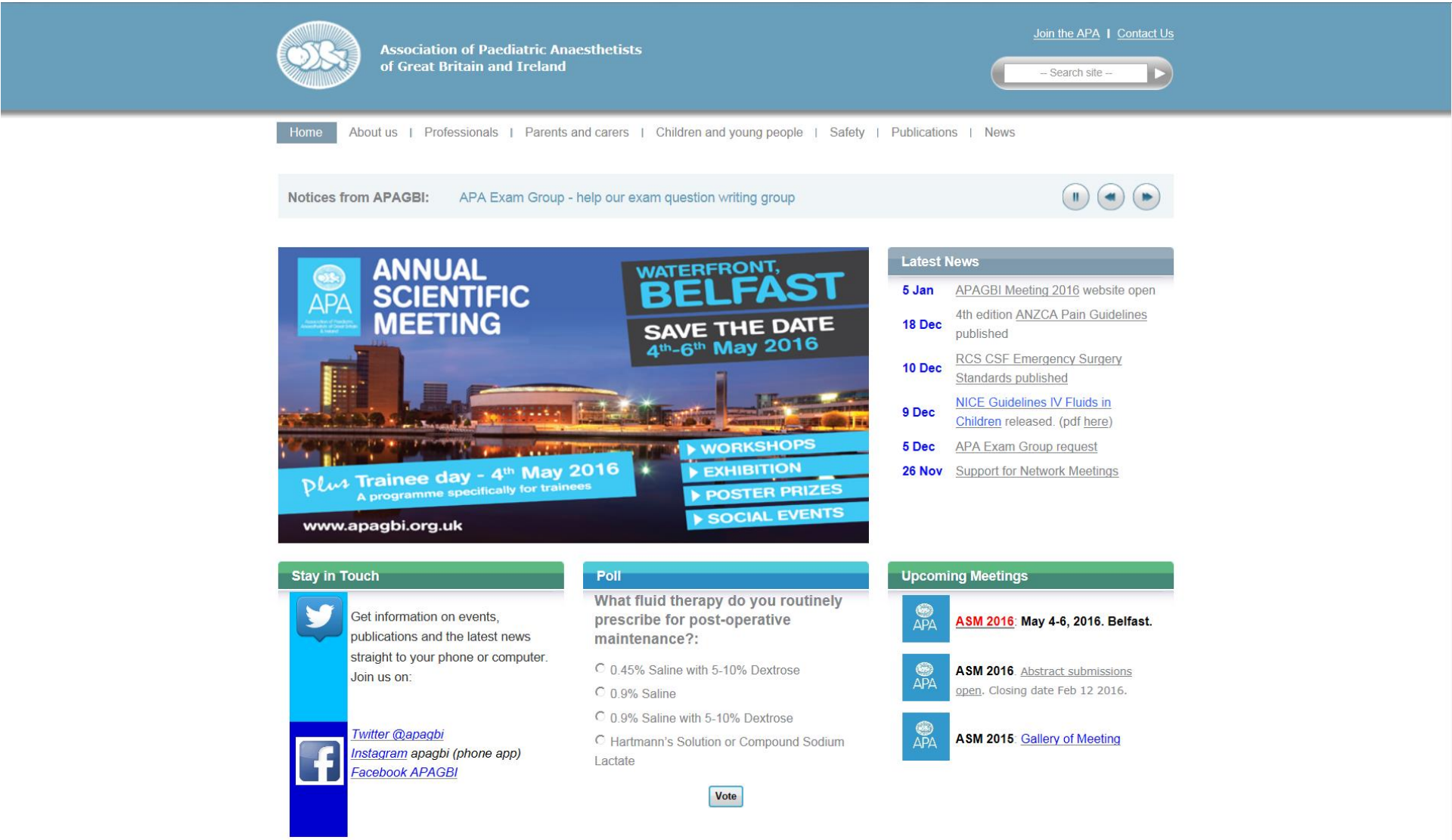
Protocollen geven aan hoe lokaal uitvoering wordt gegeven aan beroepskaders, -normen, standpunten en richtlijnen. Protocollen worden lokaal/plaatselijk vastgesteld, rekening houdend met de typische omstandigheden van de eigen praktijk en het ziekenhuis. Het opstellen van protocollen is een eigen verantwoordelijkheid van afdelingen en maatschappen anesthesiologie. De protocollen van de Sectie Kinderanesthesiologie van de NVA zijn een handvat om hieraan lokaal invulling te geven.

Perioperatief Vochtbeleid Bij Kinderen

Inhoud

Wilhelmina Children's Hospital

APA website (www.apagbi.org)



Poll question 1

- What fluid would you routinely prescribe for **post**operative maintenance?

A. NaCl 0.45% + glucose 2.5%
B. NaCl 0.9% + glucose 5%
C. NaCl 0.9% or Ringer's acetate/lactate

Poll question 2

- Which is true about hypoglycaemia?

A. Children easily become hypoglycaemic intraoperatively, because of their high metabolic rate and low glycogen reserves
B. Children seldomly become hypoglycaemic intraoperatively
C. The above are both incorrect

Poll question 3

- Which is true about sodium (Na)?

A. Children do not deal well with administered Na; so give them hypotonic iv fluids to prevent hypernatraemia
B. Children easily become hyponatraemic intraoperatively; so give them enough Na
C. The above are both incorrect

Take Home Messages

Isotonic iv fluids pre-, intra-, and postoperatively

Hyponatraemia is the most common electrolyte disturbance in children

There is a risk for hypoglycaemia in children at risk

Outline

- Fluid requirements
  - Maintenance
  - Deficits
- Electrolyte requirements
  - Tonicity
  - Hyponatraemia
- Energy requirements
  - Hyper- and hypoglycaemia
- Wrapping it up

Fluid requirements

- Aim is to maintain homeostasis and cardiovascular stability pre-, intra-, postoperatively, *taking into account the influence of surgery, surgical stress and anaesthetics*

- Maintenance
- Deficits

THE MAINTENANCE NEED FOR WATER IN PARENTERAL FLUID THERAPY

By Malcolm A. Holliday, M.D., and William E. Segar, M.D.
Department of Pediatrics, Indiana University Medical Center

- 0-10 kg: 100 cal/kg
- 10-20 kg: 1000 cal + 50 cal/kg over 10 kg
- 20+ kg: 1500 cal + 20 cal/kg over 20 kg
- 100 ml H2O/100 cal/day → 100 ml/kg/day

- **1957!**

PEDIATRICS
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

The 4-2-1-rule for maintenance

Body weight	Maintenance need / h
0-10 kg	4 ml/kg
11-20 kg	40 ml + 2 ml/kg for every kg between 11 and 20 kg
>20 kg	40 + 20 + 1 ml/kg for every kg over 20 kg

Deficits

- Preoperatively
  - Fasting: maintenance need x no. hours fasting
  - Fever: + 10% / ^{0}C above 37.5 ^{0}C
  - GI losses: vomiting, diarrhea, bowel prep
- Intraoperatively
  - Surgical bloodloss
  - Interstitial fluid shift
- Postoperatively
  - Surgical bloodloss
  - Interstitial fluid shift

- Replenish fasting deficit?
- 10 ml/kg in 1st hour
- 50% in 1st hour, 50% in 2nd-3rd
- 10-20 ml/kg bolus if hypovolaemic
- Replace ongoing losses

Electrolytes

- Solutes

- Tonicity: the capacity of a fluid to generate osmotic force over a semi-permeable membrane (in vivo)
- Osmolarity: number osmoles of solute particles in a volume of fluid (penetrating and non-penetrating)

- All Guidelines stress isotonicity of iv fluids in children

Na and hypotonicity

- Na is most important kation extracellularly, and in iv fluids
- Until recent the administration of hypotonic fluids was commonplace
- Post ≥ pre > intraoperatively
  - Snaith, PA 2008: 94% pre, 29% intra, 92% post
- Usually fluids like NaCl 0.45% or 0.225%...

Hypotonic fluid

- Nacl 0.45% / glucose 2.5%
- Isoosmolar
- “In vitro isotonic”
- In vivo hypotonic!

- Na 77 mmol/l

Hyponatraemia

- Tissue oedema
- Neurological symptoms: oedema, headache, nausea, lethargy
- Children at risk!
  - At relatively high [Na] symptomatic
    - Na < 125: 50% symptomatic
  - Higher ratio brain/intracranial volume
  - Limited Na excreting capacity brain
  - Postoperatively: ADH

ADH secretion in postoperative and ill children

- 2-3 days
- With pulmonary and neurological disease
- After cardiac-, neuro- en spinal surgery
- ADH ↑ in 84% of children after minor surgery
- Non-osmotic stimuli: pain, stress, fear, PONV, morphine

- Waterretention

- Reduce waterintake
- Probably reduce maintenance rate to 50-80%

Hyponatraemic encephalopathy

- Diminished consciousness, respiratory insufficiency, seizures, herniation, coma, death

- Moritz: 50 cases in literature
  - 50% mortality
  - 50% postoperatively
- Arieff, Moritz:
  - 8.4% mortality
  - 0.5% incidence
- Several deaths in healthy children undergoing elective surgery (UK)
  - 2007: Patient Safety Warning by National Patient Safety Agency

ADH + hypotonic fluid = hyponatraemia

- Hypotonic fluids postoperatively: 20-35%

- Isotonic fluids
- RR 0.48 (CI 95% 0.38-0.60)
- No hypernatraemia or overhydration

Isotonic versus hypotonic solutions for maintenance intravenous fluid administration in children (Review)

McNab S, Ware RS, Neville KA, Choong K, Coulthard MG, Duke T, Davidson A, Dorofaeff T

THE COCHRANE COLLABORATION®

NICE

- Use isotonic crystalloids that contain sodium in the range 131-154 mmol/litre

National Clinical Guideline Centre

IV fluids in children

Intravenous fluid therapy in children and young people in hospital

NICE Guideline NG29

Methods, evidence and recommendations

December 2015

Commissioned by the National Institute for Health and Care Excellence

NICE "IV fluids in children"

IV fluids in children

Intravenous fluid therapy in children and young people in hospital

NICE Guideline NG29

Methods, evidence and recommendations

December 2015

Table 6: Intravenous fluid types for children and young people

Fluid with recommendation reference	Fluid type[a]	Osmolality (compared with plasma)	Tonicity (with reference to cell membrane)	Sodium content (mmol/litre)	Potassium content (mmol/litre)
Isotonic crystalloids that contain sodium in the range 131–154 mmol/litre [10, 11, 17, 26, 29, 32]	0.9% sodium chloride	Isosmolar	Isotonic	154	0
	Hartmann's solution	Isosmolar	Isotonic	131	5
Isotonic crystalloids with glucose that contain sodium in the range 131–154 mmol/litre [21]	0.9% sodium chloride with 5% glucose	Hyperosmolar	Isotonic	150	0
Hypotonic fluids [29, 32]	0.45% sodium chloride with 5% glucose	Hyperosmolar	Hypotonic	75	0
	0.45% sodium chloride with 2.5% glucose	Isosmolar	Hypotonic	75	0
	0.45% sodium chloride	Hyposmolar	Hypotonic	75	0
	5% glucose	Isosmolar	Hypotonic	0	0
	10% glucose	Hyperosmolar	Hypotonic	0	0

(a) Fluids given are examples of appropriate fluids; for further details, see the British national formulary for children.

How about colloids?

IV fluids in children

Intravenous fluid therapy in children and young people in hospital

NICE Guideline NG29

Methods, evidence and recommendations

December 2015

- Did not make it into the summary
- No convincing evidence for clinical benefit of synthetic and non-synthetic colloids
- Not cost-effective
- Caution in situations with capillary leak
- Sepsis, trauma, perioperatively

Coffee and dehydration

High dose caffeine increases RBF and inhibits Na reabsorption

After abstinence caffeine works as a mild diuretic

When you feel you need a coffee you may have experienced a period of reduced fluid intake that reduces your urine production

Effect of coffee on concentration: high interindividual variability

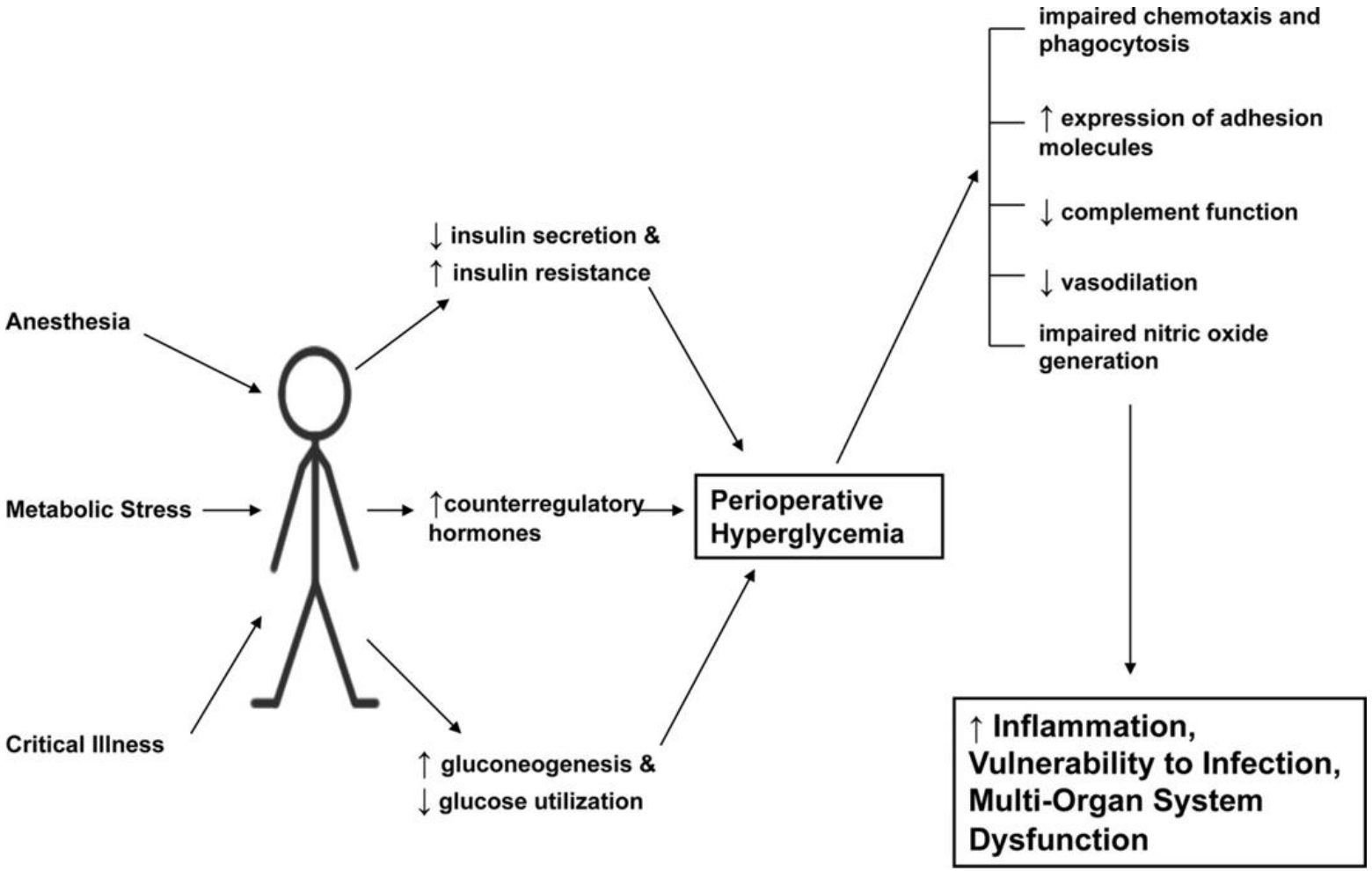
Wilhelmina Children's Hospital

Hypoglycaemia

- "Children easily become hypoglycaemic"
- Studies from the 1980s: 0 - 10%
- Old-fashioned fasting rules
- Recent: 0 - 0.25%?

- Neurological sequelae
  - Superficial cortex and hippocampus

Glucose response



Lipshutz, *Anesthesiology* 2009; 110: 408-21

Hyperglycaemia: consequences

- Osmotic diuresis
  - Glucose >10 mmol/l : dehydration and elektrolyte disturbances
- Increased injury ischaemic event CNS
- Infection rate ↑

- Administering glucose 10%, 5%, 2.5%: hyperglycaemia
- Glucose requirements under GA close to basal requirement

Glucose-containing fluids intraoperatively

- Ayers, PA 2001 10-75%
- Soderlind, PA 2001 40-70%, 50-90%
- Almenrader, PA 2009 40%

- Sümpelmann: Vollelektrolytlösung + 1% glucose
  - 2010. n=144 < 4 y, 10 ml/kg/h, no hypo, no hyper
  - 2011. n=66 neonates, 10 ml/kg/h, no hypo, no hyper

GUIDELINES

European consensus statement for intraoperative fluid therapy in children

Robert Sümpelmann, Karin Becke, Peter Crean, Martin Jöhr, Per-Arne Lönnqvist, Jochen M. Strauss and Francis Veyckemans

The intraoperative infusion of isotonic solutions with 1–2.5% glucose in children is considered well established use in Europe and other countries. Unfortunately, a European marketing authorisation of such a solution is currently missing and as a consequence paediatric anaesthetists tend to use suboptimal intravenous fluid strategies that may lead to serious morbidity and even mortality because of iatrogenic hyponatraemia, hyperglycaemia or medical errors. To address this issue, the German Scientific Working Group for Paediatric Anaesthesia suggests a European consensus statement on the composition of an appropriate intraoperative solution for infusion in children, which was discussed during a working session at the 2nd Congress of the European Society for Paediatric Anaesthesiology in Berlin in September 2010. As a result, it was recommended that an intraoperative fluid should have an osmolarity close to the physiologic range in children in order to avoid hyponatraemia, an addition of 1–2.5% instead of 5% glucose in order to avoid hypoglycaemia, lipolysis or hyperglycaemia and should also include metabolic anions (i.e. acetate, lactate or malate) as bicarbonate precursors to prevent hyperchloraemic acidosis. Thus, the underlying intention of this consensus statement is to facilitate the granting of a European marketing authorisation for such a solution with the ultimate goal of improving the safety and effectiveness of intraoperative fluid therapy in children.

Eur J Anaesthesiol 2011;28:000–000

Keywords: acid–base, children, glucose, intraoperative fluids, osmolarity, sodium

Glucose-containing iv fluids

- In children at risk for hypoglycaemia
  - Cachexia
  - Metabolic disease
  - Severe infections, sepsis
  - Term and premature neonates
  - Ex-prematures < 60 weeks postconception
  - Children with preoperative infusion of glucose or TPN
  - Long duration of fasting and/or surgery

Recommendations

- Aim for [glucose] 3.5-10 mmol/l
- Monitoring!

- Glucose 10%
- Or add 10 ml glucose 50% to 500 ml isotonic fluid: glucose 1%

- Hypo: 2 ml/kg glucose 10%
- TPN or glucose preop: continue

Patient	Dose mg/kg/min	Rate gluc 10% ml/kg/h
Child	2	1.2
Infant	3	1.8
Neonate	3-5	1.8 – 3
Premature	5-6	3 – 3.6
Crit ill infant	5-8	3 – 4.8

Postoperative fluid management

- Glucose requirements (much) higher
- ADH, water retention
- Monitor electrolytes and glucose

Wrapping it up

Preoperatively

- Sugary clear fluids 0 – 2h preoperatively
- IV: isotonic, 4-2-1-rule, add glucose with very long fasting

Intraoperatively

- Compensate for deficits
  - maintenance x h of fasting = deficit
  - 1. 50% in 1st h, 50% in subsequent 2 hours
  - 2. 1st h 10 ml/kg/h
- After compensation: 4-2-1-rule
  - …plus an estimated volume for evaporation wound, bloodloss, interstitial shift
- With hypovolaemia 10 - 20 ml/kg bolus
- Always isotonic crystalloid
- Healthy, > 1 month, short fast, postop oral intake allowable: glucose-free

Intraoperatively (2)

- Do not exclusively use fluids with glucose > 2%
- Aim for [glucose] 3.5-10 mmol/l
- Glucose needs to be dose prescribed
- Monitor [glucose]
- Continue glucose-containing fluids administered preop

Postoperatively

- 4-2-1-rule
- Or reduce to 50-80% of 4-2-1
- Isotonic and glucose 5%
  - NaCl 0.45% / glucose 2.5% = too little salt and too little sugar
  - NaCl 0.9% / glucose 5%

Poll question 1

- What fluid would you routinely prescribe for postoperative maintenance?

- NaCl 0.45% + glucose 2.5%
- NaCl 0.9% + glucose 5%
- NaCl 0.9% or Ringer's acetate/lactate

Poll question 1

- What fluid would you routinely prescribe for postoperative maintenance?

- NaCl 0.45% + glucose 2.5%
- NaCl 0.9% + glucose 5%
- NaCl 0.9% or Ringer's acetate/lactate

Poll question 2

- Which is true about hypoglycaemia?

- Children easily become hypoglycaemic intraoperatively, because of their high metabolic rate and low glycogen reserves
- Children seldomly become hypoglycaemic intraoperatively
- The above are both incorrect

Poll question 2

- Which is true about hypoglycaemia?

- Children easily become hypoglycaemic intraoperatively, because of their high metabolic rate and low glycogen reserves
- Children seldomly become hypoglycaemic intraoperatively
- The above are both incorrect

Poll question 3

- Which is true about sodium (Na)?

- Children do not deal well with administered sodium (Na); so give them hypotonic iv fluids to prevent hypernatraemia
- Children easily become hyponatraemic intraoperatively; so give them enough sodium (Na)
- The above are both incorrect

Take Home Messages

Isotonic iv fluids pre-, intra-, and postoperatively

Hyponatraemia is the most common electrolyte disturbance in children

There is a risk for hypoglycaemia in children at risk

Time for your questions!

g.jonker-4@umcutrecht.nl

http://www.apagbi.org.uk/sites/default/files/images/NICE%20Fluids%20Full%20guideline%2020151209.pdf

http://www.anesthesiologie.nl/uploads/kwaliteit/SKA_protocol_PerioperatiefVochtbeleid_201308.pdf

Wilhelmina Children's Hospital

Pediatrich electrolyte requirement

- “Half 4-2-1-rule”

Body weight	Na, K requirement / 24 h
0-10 kg	2 mmol/kg
11-20 kg	20 mmol + 1 mmol/kg for every kg between 11-20 kg
>20 kg	20+ 10+ 0.5 mmol/kg for every kg above 20 kg

Neonates

- Physiological decrease extracellular component
  - Lower fluid requirement in first week
  - 70 → 150 ml/kg/d
- Prematures larger body surface area, immature skin
  - Laregr fluid requirements than term neonate
  - + 20 ml/kg/d

Neonates (2)

- Especially prematures:
  - Immature kidney, lessNa reabsorption, natriuresis
  - Tend to get hypernatraemia
  - Little to no Na iv in first days
  - Less HCO3 reabsorption: tend to get metabolic acidosis
  - Later tend to get hyponatriaemia, esp with hypotonic fluids