Consensus Guidelines for IV Fluid Management:
Northern California Pediatric Hospital Medicine Consortium

Executive summary

Objectives
- Standardize care of pediatric patients who require maintenance IV fluids in the hospital
- Reduce utilization of maintenance IV fluids
- Use best available evidence to guide selection and monitoring of appropriate maintenance IV fluids with consideration for patient-specific factors

Recommendations
- Maintenance IV fluids are appropriate for euvolemic patients who cannot take adequate enteral fluids
- Calculate hourly maintenance fluid rates using standard weight-based formula (4-2-1 rule)
- Do not use maintenance IV fluids at rates above calculated maintenance, and calculate replacement for ongoing fluid losses separately from maintenance
- In patients older than 28 days who do not meet exclusion criteria, use isotonic fluids
- Use caution and select fluids on a case-by-case basis for patients with the following conditions: Renal disease/renal dysfunction, endocrine disorders causing electrolyte abnormalities, neurosurgery or brain injury, severe cardiac disease, ICU Level of Care (PICU or NICU), severe malnutrition, known metabolic disease, sickle cell patients, liver failure/hepatic dysfunction, high extrarenal water loss
- Do not use ¼ NS for maintenance fluids outside the neonatal period
- Add 5% dextrose to maintenance fluids for patients with limited or no oral nutritional intake
- Add potassium to maintenance fluids unless contraindicated
- Check serum electrolytes (with attention to sodium, chloride, bicarbonate) at 24 hours after initiation of maintenance IV fluids for patients receiving >75% of maintenance needs via IV; re-check serum electrolytes as indicated
- Monitor strict intake and output, weight, blood pressure, and signs of fluid overload daily in patients receiving maintenance IV fluids
- Discontinue maintenance IV fluids as soon as patients can take adequate enteral fluids

Methods
This guideline was developed through local consensus based on published evidence and expert opinion as part of the UCSF Northern California Pediatric Hospital Medicine Consortium.

Metrics Plan

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Consensus Clinical Guidelines

Inclusion criteria

- Euvolemic general pediatric (surgical and non-surgical) patients in inpatient setting requiring IV fluids
- Otherwise healthy euvolemic pediatric patients in ED setting awaiting admission

Exclusion criteria (*note:* guidelines may apply but fluids must be carefully managed)

- Renal disease/renal dysfunction
- Endocrine disorders causing electrolyte abnormalities
- Neurosurgery or brain injury
- Severe cardiac disease
- ICU Level of Care (PICU or NICU)
- Severe malnutrition
- Known metabolic disease
- Sickle cell patients
- Liver failure/hepatic dysfunction
- High extrarenal water loss

PART I: Background / rationale

- IV fluid administration is not a completely benign intervention, but selection of maintenance IV fluid rate and composition that is tailored more precisely to specific patients / disease states can improve safety and reduce IV fluid-related adverse effects including iatrogenic hyponatremia
    - Infants have less urine concentrating ability than adults and maximum concentrating ability is not reached until approximately 18 months. In addition, larger body surface area per volume with increased insensible losses in infants & small children → more hypotonic fluids (replace more free water).

- Growing pediatric literature on iatrogenic hyponatremia associated with administration of hypotonic IV fluids (in surgical and non-surgical patients), likely due to a combination of hypotonic fluid administration and fluid retention related to elevated ADH secretion:
    - Risk of hyponatremia is most well documented in post-surgical patients but has also been described in general pediatric medical patients (add 2016 citation)

        - There is a small risk of seizures associated with hyponatremia

- Literature does not demonstrate increased risk of hypernatremia in patients receiving isotonic IV fluids, but there is inadequate data about other potential adverse effects of isotonic fluids such as hypertension, fluid overload (edema), or hyperchloremic metabolic acidosis

- IV fluid composition & rate
    - Definitions:
        - Isotonic = normal saline (0.9% NS), lactated ringers (LR), Plasmalyte
        - Hypotonic = 0.45% NS (½ NS) < 0.2% NS (¼ NS)
        - See APPENDIX 1 – IV fluid composition

PART II: Selection of IV Fluids for Pediatric Inpatients

- Identifying patients at risk for elevated ADH
    - Acute conditions or disease states with elevated anti-diuretic hormone (ADH) are most at risk for development of hyponatremia:
        - Pulmonary disease (particularly pneumonia)
        - Pain
        - CNS disease
        - Gastroenteritis and nausea/vomiting in general
        - Recent surgery
    - *NOTE* – clinical signs of excessive ADH secretion include:
        - Hyponatremia and hypo-osmolality
        - High urine sodium and osmolality
        - Absence of clinical signs of hypovolemia
        - Weight may be normal or increased
- Choice of IV Fluids

  Sodium (Na) Content
        - ≥28 days: Isotonic fluid @ full maintenance (most common choice 0.9% NS, Plasmalyte also well-studied)
        - <28 days: ½ (0.45%) NS @ full maintenance rate
            - **¼ NS should not generally be used outside the neonatal period

  Dextrose Content
    - Add dextrose to maintenance IV fluids for all pediatric patients who are NPO or are unable to take adequate oral nutritional intake
        - Contraindication: hyperglycemia (e.g. neurotrauma)

  Potassium Content
    - Add potassium to maintenance IV fluids for most pediatric patients
        - Contraindication: patients with conditions that lead to impaired ability to clear potassium and/or hyperkalemia
            - Renal insufficiency/failure
            - Systemic acidosis
            - Use of potassium-sparing diuretics

- Adrenal insufficiency
- Severe tissue damage such as burns, rhabdomyolysis

- Ensure adequate UOP prior to adding potassium to fluids
- Appropriate potassium content:
  - < 12 mo → 10 meq/L KCl
  - ≥ 12 mo → 20 meq/L KCl
- *NOTE:* potassium should never be added to bolus IV fluids

Deficit Replacement:

- Use isotonic fluid (0.9% NS) for fluid deficit replacement / boluses

***Use caution in patients receiving large volumes of IV fluids for deficit replacement (e.g. AGE) and consider checking labs more frequently (at least q 24 hours) in these patients. In patients receiving higher than maintenance rate of IV fluids, consider using a more physiologic electrolyte solution like LR or Plasmalyte.*

- Calculating IV Fluid Rate/Volume
  - Caution should be exercised in using "maintenance" IV fluids at rates above the calculated maintenance; fluid replacement should be calculated separately to account for ongoing losses
  - 4-2-1 rule (100-50-20 rule)
    - 4 mL/kg/hr (100 mL/kg/day) for the first 10kg PLUS
    - 2 mL/kg/hr (50 mL/kg/day) for the second 10kg PLUS
    - 1 mL/kg/hr (20 mL/kg/day) for each kg over 20kg
    - Maximum rate of 120 mL/hr
    - *NOTE:* use dose-calculation weight or ideal body weight

Part III: When and How to Use IV Fluids

"Maintenance" IV fluids

- Indications:
  - Euvolemic medical and surgical patients who cannot take adequate enteral fluids
  - Do *not* use maintenance IV fluids in dehydrated patients; rehydrate patient first, then consider starting maintenance IV fluids
- Consider current fluid status before initiating IV fluids:
  - Need for fluid restriction
  - Need for fluid resuscitation
- Monitoring:
  - Strict intake & output (particular attention to ongoing losses)
  - Daily weight
  - Signs/symptoms of fluid retention (at least daily):
    - Peripheral or pulmonary edema (*note:* patients lying in bed may develop dependent edema in back/buttocks)
    - Elevated blood pressure
    - Increased weight
  - Electrolyte monitoring:
    - Check electrolytes ~24-36 hrs after initiation for patients receiving >75% of maintenance fluid needs via IV; re-check as clinically indicated (at least

every 48 hours)
        - Follow serum sodium, chloride, bicarbonate for possible hypernatremia, hyperchloremic metabolic acidosis, hyponatremia
- Consider factors that indicate readiness to wean IV fluid (daily on rounds):
    - At or approaching baseline mental status
    - Clinically stable or improving clinical status
    - Demonstrated ability to take enteral fluids with subsequent urine output
    - Presence of bowel sounds / return of bowel function (post-surgical patients)
    - Well-controlled pain and nausea

- When to Consider PN (Parenteral Nutrition): dependent on expected clinical trajectory
    - Hospitals without ability to obtain central access and/or who do not stock parenteral nutrition (PN) fluids:
        - Consider patient's trajectory after 3 days on IVF taking <50% of nutrition enterally
            - If clinical status not improving or worsening, consider transfer to tertiary center or consult with Pharmacy/Nutrition for capabilities
    - Hospitals with ability to obtain central access and parenteral nutrition
        - Consider consulting nutrition and starting PN after 5-7 days on IVF taking <50% of nutrition enterally

- Weaning & discontinuation of IV fluids:
    - Discontinue IV fluids and saline-lock IV as soon as clinically appropriate
    - *NOTE:* use caution with discontinuing IV fluids in patients with ongoing fluid losses

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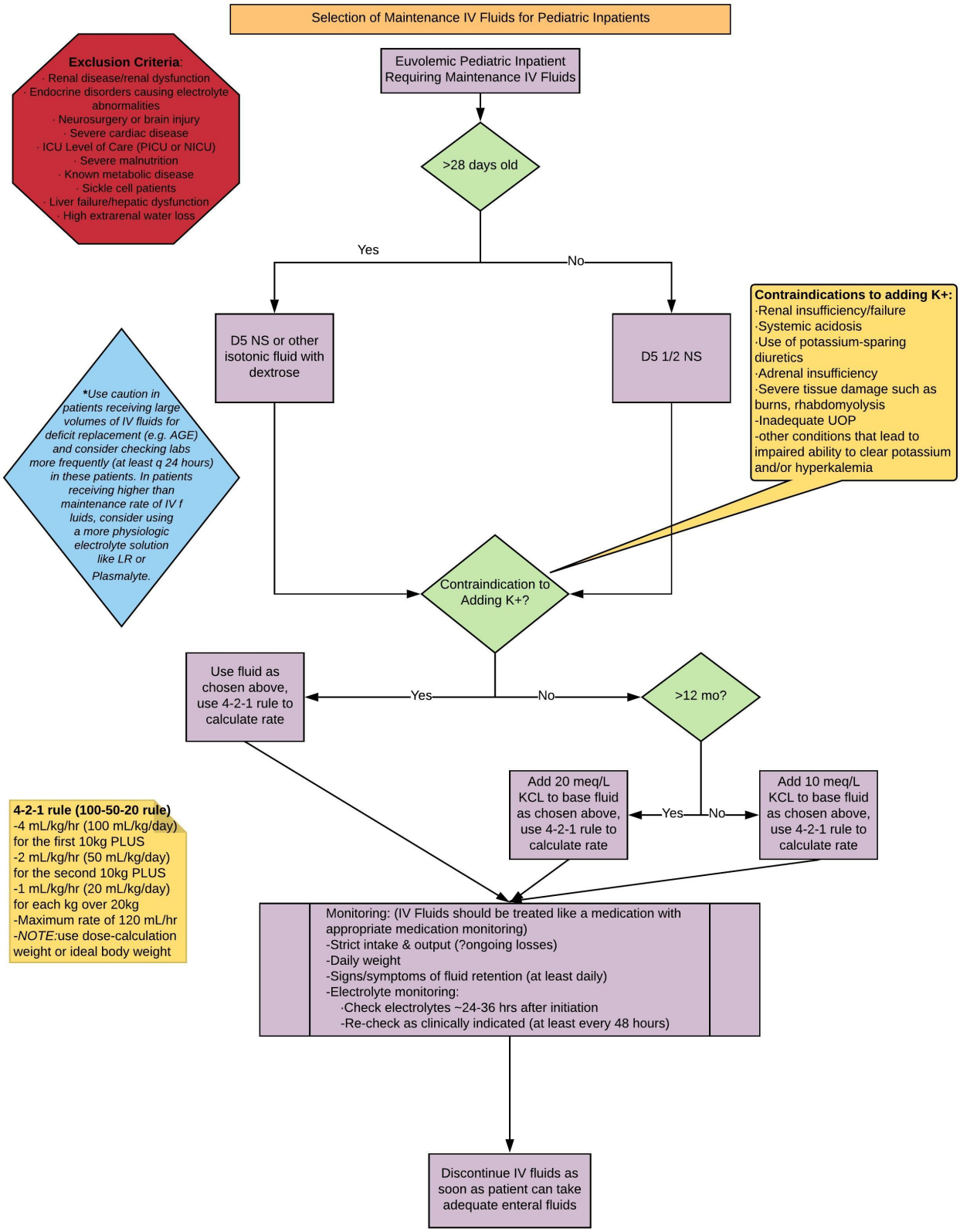
APPENDIX 1: IV Fluid Composition

SOLUTION	Na+ (mEq/L)	Cl- (mEq/L)	K+ (mEq/L)	Ca++ (mEq/L)	Lactate (mEq/L)	Magnesium (mmol/L)	Acetate (mmol/L)	Gluconate (mmol/L)	Glucose (gm/L)
Isotonic									
NS (0.9%)	154	154	0	0	0	0	0	0	0
LR	130	109	4	3	28	0	0	0	0
Plasmalyte	140	98	5	0	0	1.5	27	23	0
Hypotonic									
½ NS (0.45%)	77	77	0	0	0	0	0	0	0
¼ NS (0.2%)	31	31	0	0	0	0	0	0	0
D5W	0	0	0	0	0	0	0	0	50

APPENDIX 2: Maintenance IV Fluid Selection Clinical Pathway


Selection of Maintenance IV Fluids for Pediatric Inpatients
Euvolemic Pediatric Inpatient Requiring Maintenance IV Fluids
Exclusion Criteria:
· Renal disease/renal dysfunction
· Endocrine disorders causing electrolyte abnormalities
· Neurosurgery or brain injury
· Severe cardiac disease
· ICU Level of Care (PICU or NICU)
· Severe malnutrition
· Known metabolic disease
· Sickle cell patients
· Liver failure/hepatic dysfunction
· High extrarenal water loss
>28 days old
Yes
No
D5 NS or other isotonic fluid with dextrose
D5 1/2 NS
*Use caution in patients receiving large volumes of IV fluids for deficit replacement (e.g. AGE) and consider checking labs more frequently (at least q 24 hours) in these patients. In patients receiving higher than maintenance rate of IV f luids, consider using a more physiologic electrolyte solution like LR or Plasmalyte.
Contraindications to adding K+:
·Renal insufficiency/failure
·Systemic acidosis
·Use of potassium-sparing diuretics
·Adrenal insufficiency
·Severe tissue damage such as burns, rhabdomyolysis
-Inadequate UOP
-other conditions that lead to impaired ability to clear potassium and/or hyperkalemia
Contraindication to Adding K+?
Use fluid as chosen above, use 4-2-1 rule to calculate rate
Yes
No
>12 mo?
Add 20 meq/L KCL to base fluid as chosen above, use 4-2-1 rule to calculate rate
Yes
No
Add 10 meq/L KCL to base fluid as chosen above, use 4-2-1 rule to calculate rate
4-2-1 rule (100-50-20 rule)
-4 mL/kg/hr (100 mL/kg/day) for the first 10kg PLUS
-2 mL/kg/hr (50 mL/kg/day) for the second 10kg PLUS
-1 mL/kg/hr (20 mL/kg/day) for each kg over 20kg
-Maximum rate of 120 mL/hr
-NOTE:use dose-calculation weight or ideal body weight
Monitoring: (IV Fluids should be treated like a medication with appropriate medication monitoring)
-Strict intake & output (?ongoing losses)
-Daily weight
-Signs/symptoms of fluid retention (at least daily)
-Electrolyte monitoring:
·Check electrolytes ~24-36 hrs after initiation
-Re-check as clinically indicated (at least every 48 hours)
Discontinue IV fluids as soon as patient can take adequate enteral fluids

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Wang J, et al. Isotonic versus Hypotonic Maintenance IV Fluids in Hospitalized Children: A Meta-Analysis. *Pediatrics*. 2014; 133: 105-113.

MAJOR U.S. CHILDREN'S HOSPITAL CLINICAL PATHWAYS:

IV Fluid Clinical Pathways

Children's Hospital of Philadelphia (CHoP):
http://www.chop.edu/clinical-pathway/fluid-administration-continuous-iv-clinical-pathway-inpatient

Seattle Children's Hospital:
http://www.seattlechildrens.org/healthcare-professionals/gateway/pathways/

Stanford Children's Hospital:
pednephrology.stanford.edu/secure/.../FluidElectrolyteTherapy.doc