IV Fluid Therapy: Maintenance (Euvolemic)

Inpatient

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Verify that patient is appropriate for this pathway

Euvolemic and Not candidate for enteral fluids (oral or NG/G/GJ-tube) to maintain euvolemia ?

- No or Unsure → Go to "IV Fluid Therapy: Bolus (Hypovolemic)" Algorithm
- Yes ↓

Maintenance IV Fluids

- Maintenance IV Fluid Selection (LR[$], NS[$], PL[$$$])
- Calculate maintenance rate
- Determine need for IV Fluid Additives (potassium and dextrose)
- Compatibility Considerations

↓

Monitoring

- Clinical volume status
- Input/Output
- Daily weight
- Scheduled chem7 (at minimum by 48h of IVF)

↓

Electrolyte abnormality? (hyperchloremic acidosis, hypo- or hypernatremia) and/or **Hypovolemia?** or **Signs of Volume Overload?**

- Yes →
  - Verify continued need for IVFs or discontinue
  - Reassess Maintenance IV Fluid selection
  - Reassess risk factors for increased ADH
  - **Individualize management** based on patients condition

  → Reassess Daily
- No ↓

Reassess Daily
Tolerates oral fluids or NG/G/GJ-tube fluids to maintain euvolemia?

- No →
  - By **day 5** of mIVF, start plans for enteral and/or parenteral nutrition support[32]
  - By **day 7** of mIVF, should be transitioned to enteral and/or parenteral nutrition

  → Monitoring
- Yes ↓

Off Pathway.
Continue with enteral fluids.
Monitor I/Os.

Calculating IV Fluid Rate

Holliday-Segar "4-2-1" Rule:

- First 1-10 kg = 4 mL/kg/hr
- Next 11-20 kg = 2 mL/kg/hr
- Next > 20 kg = 1 mL/kg/hr
- Add together for maintenance rate
- Calculation example

BSA method:

- BSA (m^2) × 1600 mL/m^2/day = Daily requirement

Maximum Rate:
100 mL/hr is an appropriate maximum rate in most patients

IV Fluid Therapy: Bolus (Hypovolemic)

Inpatient

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Verify that patient is appropriate for this pathway

Additional Guidance for Degree of Dehydration Assessment

Is an accurate **pre-illness weight** available to determine dehydration severity?

Yes →

Gold Standard for % Dehydration:

*(PreIllnessWt - CurrentWt) / (PreIllnessWt) * 100 = % of fluid deficit*

No →

Clinical Findings to Assess Dehydration Severity

1. Poor overall appearance
2. Capillary refill >2 seconds
3. Abnormal respirations
4. Decreased skin elasticity
5. Absent tears
6. Dry mucous membranes
7. Sunken eyes
8. Abnormal radial pulse
9. Tachycardia
10. Decreased urine output

Severe/Extreme Dehydration?
>10% or ≥7 findings

Yes →

- Consider push-pull administration of fluids
- Consider ICU involvement (ACT)

→ **IV Fluid Bolus**
(20 mL/kg) Isotonic fluid
Bolus IV Fluid Selection

No →

Minimal to Moderate Dehydration
<10% or ≤6 findings

Bolus Dosing Guidance

Is fluid bolus orally or via NG/G/GJ-tube appropriate?

- **No** → IV Fluid Bolus
- **Yes** → **Off Pathway.** Continue with enteral fluids. Monitor I/Os.

Consider NG in patients with PO fluid aversion. Shared decision-making with patient/family

Patients requiring multiple boluses should be frequently reassessed for signs of shock or fluid overload. Low threshold for PICU involvement (ACT).

After IV Fluid Bolus: Reassess vital signs & clinical findings: **Moderate or Extreme dehydration?**

- **No** → Attempt enteral fluids if feasible
- **Yes** → **2nd IV Fluid Bolus**
(20 mL/kg) Isotonic fluid

Reassess vital signs & clinical findings: **Moderate or Extreme dehydration?**

- **No** → Attempt enteral fluids if feasible
- **Yes** → **3rd IV Fluid Bolus**
(20 mL/kg) Isotonic fluid
  - Revisit differential diagnosis
  - Consider ACT and vasopressor support
  - **Individualized management.**
  - **Off pathway**

Attempt enteral fluids if feasible

Tolerates oral fluids or NG/G/GJ-tube fluids to maintain euvolemia?

- **Yes** → **Off Pathway.** Continue with enteral fluids. Monitor I/Os.
- **No** → Go to "IV Fluid Therapy: Maintenance (Euvolemic)" Algorithm

Pre-Pathway Validation

Background
This algorithm is meant to apply to patients who require fluid administration either to recover or maintain euvolemia. The algorithm would generally apply to patients who are unable to maintain euvolemia by enteral fluid intake alone, therefore requiring intravenous fluid administration.

Target Patient Population:

- Euvolemic but NPO
- Dehydration/Hypovolemia

Diagnostic Criteria for IV Fluid Therapy.

- Patients should undergo clinical assessment for hypovolemia or hypervolemia, inclusion/exclusion criteria, as well as candidacy for enteral fluid supplementation should occur to ensure fluids are required.

Consider Alternate Therapy When:

- Enteral fluid administration is an option

Diagnostic Time-Out

- What else could this be?
- Consider utilizing a diagnostic checklist

Inclusion Criteria

- IV Fluids needed to rehydrate or maintain euvolemia
- Unable to rehydrate or maintain euvolemia by enteral fluid intake alone
- Prolonged NPO
-

Exclusion Criteria

- Corrected gestational age ≤ 28 days
- Patients requiring intensive care
- Acute kidney injury or chronic kidney disease
- Diabetic ketoacidosis
- Severe electrolyte derangements requiring intravenous fluid as treatment
- Oncological treatment protocol
- Increased intracranial pressure, pyloric stenosis, burns, shock
- Parenteral nutrition dependent
- Organ failure including renal, cardiac, and hepatic failure
- Fluid overloaded state (hypervolemia)
- Patients under fluid-related study

Diagnostic Timeout

Red Flags

- **Risk factors for increased ADH** & hyponatremia:
  - Stress, pain, anxiety
  - Vomiting, diarrhea
  - Infection
  - Recent surgery
  - CNS pathology
  - Medications
- Volume/Fluid overload,
- Hyperchloremic metabolic acidosis
- Hyper- or Hyponatremia
- Hyper- or Hypokalemia
- Hyper- or Hypoglycemia
- Acute Kidney Injury

Assess Degree of Dehydration

Signs of Hypervolemia (NO IVF)

Go to Maintenance (Euvolemic) Algorithm

Go to Bolus (Hypovolemic) Algorithm

Assess Degree of Dehydration

Signs and Symptoms	Degree of Dehydration		
	None or Mild	Moderate	Severe
General Condition	<5%	5 - <10%	≥10%
Infants	Thirsty; alert; restless	Lethargic or drowsy	Limp; cold, cyanotic extremities; may be comatose
Children	Thirsty; alert; restless	Alert; postural dizziness	Apprehensive; cold, cyanotic extremities; muscle cramps
Quality of radial pulse	Normal	Thready or weak	Feeble or impalpable
Quality of respiration	Normal	Deep	Deep and rapid
Skin elasticity	Pinch retracts immediately	Pinch retracts slowly	Pinch retracts very slowly (>2 sec)
Eyes	Normal	Sunken	Very sunken
Tears	Present	Absent	Absent
Mucous membranes	Moist	Dry	Very Dry
Urine output (by report of parent)	Normal	Reduced	None passed in many hours

Adapted from Gorelick MH, Shaw KN, Murphy KO. Validity and Reliability of Clinical Signs in the Diagnosis of Dehydration in Children. *Pediatrics*. 1995;99(5):1-6.

Return to Maintenance (Euvolemic) Algorithm

Return to Bolus (Hypovolemic) Algorithm

Signs of Hypervolemia/Fluid Overload

Return to Pre-Pathway Validation

Bolus Dosing Guidance

- **Need for bolus dosing determined by clinical condition, vital signs, and clinical volume status assessment**
  - Mild hypovolemia: 10-20 mL/kg bolus of isotonic crystalloid (LR, NS, PL)
  - Moderate-severe hypovolemia: 20 mL/kg isotonic crystalloid
  - In patients >50 kg, use 1000 mL and 500 mL boluses (rather than 20 mL/kg or 10 mL/kg, respectively)
  - Consider push-pull administration and ACT activation for severe hypovolemia, hypotension, refractory tachycardia, or as otherwise clinically indicated
  - Patients requiring bolus dosing should be frequently reassessed and PICU involvement (ACT) should be considered

- **Selection of fluid should be based on clinical condition and serum electrolytes at time of administration**
  - Balanced solutions (LR, PL) have lower risk of hyperchloremic metabolic acidosis and better outcomes in a variety of indications[16-28]
  - When rapid infusion needed, the first available isotonic fluid should be used
  - NS has hyper-physiological Na and Cl – may be useful for concerns of hyponatremia
  - Hypotonic solutions (0.45% saline, 0.2% saline, free water) should not be administered in a bolus dose

- **Patients with persistent severe hypovolemia, fluid-refractory or non-hypovolemic shock, and/or requirement of >2 bolus doses should be evaluated by PICU team (ACT)**

Return to Bolus (Hypovolemic) Algorithm

Bolus IV Fluid Selection

- **Lactated Ringers (LR)**[$]
  - isotonic, balanced
- **Normal Saline (NS)**[$]
  - isotonic, unbalanced
- **PlasmaLyte (PL)**[$]
  - isotonic, balanced; expensive, short supply

Human Plasma	Fluid Composition	Lactated Ringer's (LR)	0.9% Sodium Chloride (NS)	Plasma-Lyte (PL)
	Balanced or Unbalanced	Balanced	Unbalanced	Balanced
275-295	Osmolality (mOsm/kg)	273	308	295
7.35-7.45	pH	6-7.5	5	7.4
135-145	Sodium (mmol/L)	130	154	140
3.5-4.5	Potassium (mmol/L)	4	0	5
96-106	Chloride (mmol/L)	109	154	98
8.9-10.1	Calcium (mg/dL)	2.7	0	0
1.7-2.3	Magnesium (mg/dL)	0	0	3
0	Lactate (mmol/L)	28	0	0

[Return to Bolus (Hypovolemic) Algorithm]

[Further IVF Selection Guidance]

Maintenance IV Fluid Selection

- **Lactated Ringers (LR)$**
  - Isotonic, balanced (can bolus)
  - Near-physiologic
  - Dextrose, potassium may be added
- **Normal Saline (NS)$**
  - Isotonic, unbalanced (can bolus)
  - Acidic and hypernatremic; risk of hyperchloremic metabolic acidosis
  - Dextrose, potassium may be added
- **Plasma-Lyte (PL)$**
  - Isotonic, balanced (can bolus)
  - Expensive, limited availability – not first-line
  - Dextrose can NOT be added
- **0.45% Saline, 0.2% Saline**
  - Hypotonic, hyponatremic (cannot bolus)
  - Dextrose, potassium may be added
  - Not recommended first-line

Human Plasma	Fluid Composition	Lactated Ringer's (LR)	0.9% Sodium Chloride (NS)	0.45% Sodium Chloride (½ NS)	Plasma-Lyte (PL)
	Balanced or Unbalanced	Balanced	Unbalanced	Unbalanced	Balanced
275-295	Osmolality (mOsm/kg)	273	308	154	295
7.35-7.45	pH	6-7.5	5	5	7.4
135-145	Sodium (mmol/L)	130	154	77	140
3.5-4.5	Potassium (mmol/L)	4	0	0	5
96-106	Chloride (mmol/L)	109	154	77	98
8.9-10.1	Calcium (mg/dL)	2.7	0	0	0
1.7-2.3	Magnesium (mg/dL)	0	0	0	3
0	Lactate (mmol/L)	28	0	0	0

Return to Maintenance (Euvolemic) Algorithm

Further IVF Selection Guidance

IV Fluids Selection Guidance

Lactated Ringer's (LR)

- Safe for bolus use.
- LR has a similar composition to human plasma.
- Multiple studies have indicated lower incidence of sodium derangements, hyperchloremic metabolic acidosis (and associated mortality), and acute kidney injury (AKI) compared to saline solutions.[16-28]
- Dextrose and additional potassium may be added to LR.
- The presence of potassium must be considered in patients at risk for hyperkalemia. In patients with these risks (i.e. tumor lysis syndrome), fluids should be ordered with expert consultation.
- Physiological studies indicate 0.9% normal saline causes hyperkalemia more frequently than LR due to acidosis causing shifting of potassium from cells.[14,29]

0.9% Sodium Chloride (NS)

- Safe for bolus use.
- NS is an isotonic solution with a hyperphysiologic levels of sodium and chloride. The elevated sodium content can be useful with concerns for hyponatremia or brain injury.
- Dextrose and potassium may be added to NS.
- Use of NS is associated with AKI and can cause a hyperchloremic metabolic acidosis which is associated with significant adverse clinical outcomes.[14,18,19,26-29]
- Concerns for hypernatremia secondary to NS usage have been less well-founded in the literature.

Plasma-Lyte (PL)

- Safe for bolus use.
- Plasma-Lyte has a similar composition to human plasma. Similar to LR, multiple studies have indicated lower incidence of sodium derangements, hyperchloremic metabolic acidosis (and associated mortality), and acute kidney injury (AKI) compared to saline solutions.[16-28]
- The presence of potassium should be considered in patients at risk for hyperkalemia, including tumor lysis syndrome.
- Plasma-Lyte cannot be made to contain dextrose. It is also expensive and available in significantly shorter supply.

0.45% Sodium Chloride (½ NS)

- Not safe for bolus use.
- ½ NS is a hypotonic solution that provides a decreased total sodium load compared to LR and NS. Dextrose and potassium may be added.
- In patients with normal physiological function, the kidneys excrete free water and prevent hyponatremia, however many hospitalized patients have risk factors for increased ADH secretion.[6,8,30] Hypotonic fluids and increased ADH secretion can put these patients at risk for hyponatremia. Significant hyponatremia is known to cause lethargy, seizures, coma, cerebral edema, and has an association with mortality.[6,8,30]
- ½ NS and other hypotonic fluids are not recommended as first-line maintenance fluids for the patients included in this guideline.[10]

Return to Maintenance (Euvolemic) Algorithm

Return to Bolus (Hypovolemic) Algorithm

IV Fluid Additives

Potassium		
Use	**Monitoring**	**Contraindications**
• NS: consider 10-20 mEq/L of K (at 1x maintenance rate). • LR: contains 4 mEq/L of K. Additional K may be added. • PL: contains 5 mEq/L of K.	• Monitor/adjust K with labs (chem7, BMP, RFP) • If adjusting fluid rate, consider adjusting K concentration	• Anuria, significant renal injury • Rhabdomyolysis • Tumor lysis syndrome • Use of K-sparing diuretics • Other pre-disposing conditions to hyperkalemia

Dextrose	
Dextrose 5% (D5)	**Dextrose 10% (D10)**
• Indicated in all patients < 1 year old with absent enteral intake • Consider in patients < 10 years old with absent enteral intake or risk factors for hypoglycemia • As otherwise clinically indicated	• Treatment for hypoglycemia

Return to Maintenance (Euvolemic) Algorithm

Compatibility

- **Ceftriaxone and LR**[15]
  - Due to calcium content of LR (risk of ceftriaxone-calcium precipitation)
  - Ceftriaxone and LR may be used if line is adequately flushed before and after administration with saline
  - Ceftriaxone should not be used with LR in patients < 28 days even with separate lines

- **Chemotherapy, Malignancy, Tumor Lysis Syndrome:**
  - Intravenous fluids guided by oncologist and chemotherapy protocol in patients admitted to oncology

- **Transfusions and LR**[13,31]
  - Packed RBCs may be administered with LR in a separate line

- **Lactic Acid and LR**[13]
  - LR contains sodium lactate, not lactic acid, and this is metabolized by the liver
  - Sodium lactate does not share lactic acid's harmful effects
  - Lactate may theoretically accumulate in patients with liver failure; fluid resuscitation in patients with known hepatic dysfunction should be done with expert consultation

Return to Maintenance (Euvolemic) Algorithm

IVF Rate Calculation

Holliday-Segar "4-2-1" rule.[2]	Example: 39kg child
• First 1-10 kg = 4 mL/kg/hr • Next 11-20 kg = 2 mL/kg/hr • Next > 20 kg = 1 mL/kg/hr • Add together for maintenance rate	• 10 kg x 4 mL/kg/hr = 40 mL/hr • 10 kg x 2 mL/kg/hr = 20 mL/hr • Remaining 19 kg x 1 mL/kg/hr = 19 mL/hr • Maintenance rate = 79 mL/hr

- It is appropriate to have a maximum fluid rate of 100 mL/hr in most patients.

Return to Maintenance (Euvolemic) Algorithm

Monitoring

- The major complications of maintenance fluid administration include volume overload, sodium derangements, hyperchloremic metabolic acidosis, potassium derangements, glucose derangements, and changes in renal function.
- Clinical volume status, weight, and intake/output should be monitored daily for all patients on mIVF.
- Serum electrolytes should be monitored in patients receiving IVFs, with strong recommendation to initiate monitoring within 48 hours of IVF initiation and then daily until IVFs have been discontinued
- If there is concern for development of hyperchloremic metabolic acidosis (chloride ≥ 110 mmol/L, bicarbonate ≤ 18 mmol/L)[19], a venous blood gas may be obtained.

Return to Maintenance (Euvolemic) Algorithm

Signs of Hypervolemia/Volume Overload

- Peripheral edema
- Hepatomegaly
- Pulmonary edema
- Hypertension
- Ascites
- Elevated jugular venous pressure

Return to Maintenance (Euvolemic) Algorithm

Metrics

Goal:
Increase evidence-based IVF ordering to minimize electrolyte abnormalities and promote earlier transition to optimal nutrition routes.

Process Measures:
1. Utilization of standardized Epic tools to order IVFs.
2. Increase rate of lab monitoring for patients receiving maintenance IVFs.

Quality Measures:
1. Minimize number of patients receiving MIVF therapy greater than 5 days.
2. Increase percentage of patients receiving balanced and isotonic IVFs (Lactated Ringers and PlasmaLyte) for non-ICU patients greater than 28 days of age.
3. Minimize incidence of hyponatremia (Na <135) and hyperchloremic metabolic acidosis (Cl >110 and concurrent CO2 <18) after initiation of maintenance IVFs for non-ICU patients greater than 28 days of age.

Balancing Measures:
1. Re-initiation of IV fluids within 48 hrs
2. Hospital LOS of patients on IV Fluids
3. Duration and cost of IV fluid therapy

Return to Maintenance (Euvolemic) Algorithm

Further IVF Selection Guidance

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Return to Maintenance (Euvolemic) Algorithm

Return to Bolus (Hypovolemic) Algorithm

Team & Process

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Origination Date: *September, 2022*

Next Revision Date: *September, 2025*

Clinical Pathway Development

This clinical pathway was developed using the process described in the NCH Clinical Pathway Development Manual Version 6, 2022. Clinical Pathways at Nationwide Children's Hospital (NCH) are standards which provide general guidance to clinicians. Patient choice, clinician judgment, and other relevant factors in diagnosing and treating patients remain central to the selection of diagnostic tests and therapy. The ordering provider assumes all risks associates with care decisions. NCH assumes no responsibility for any adverse consequences, errors, or omissions that may arise from the use or reliance on these guidelines. NCH's clinical pathways are reviewed periodically for consistency with new evidence; however, new developments may not be represented, and NCH makes no guarantees, representations, or warranties with respect to the information provided in this clinical pathway.

For more information about our pathways and program please contact: ClinicalPathways@NationwideChildrens.org

[Return to Maintenance (Euvolemic) Algorithm]

[Return to Bolus (Hypovolemic) Algorithm]