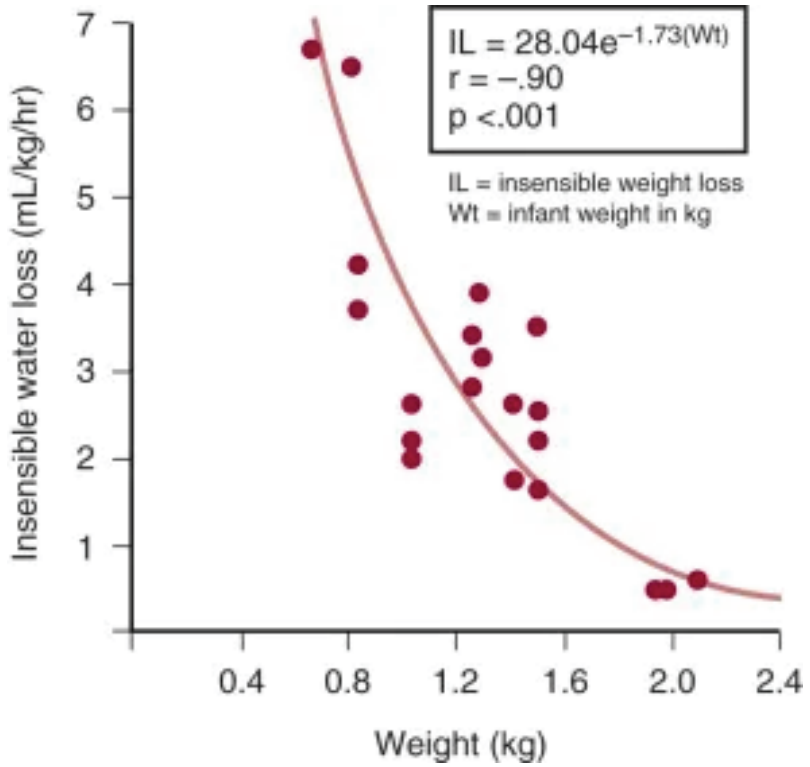
Suggested Approach to Fluid Management at 22 – 27 Weeks' Gestation

Considerations for Fluid Management

The fluid requirements for infants born at the edge of viability are both unique and complex. Intracellular fluid shifts and marked insensible water losses in the setting of immature, water-permeable skin require significant fluid replacement in the first several days of age. However, fluid requirements are often influenced by critical diagnoses such as respiratory distress syndrome, patent ductus arteriosus, necrotizing enterocolitis, etc. Appropriate fluid management among these infants is crucial for decreasing morbidity and increasing survival outcomes.

Insensible Water Loss (IWL) is greatest in the tiniest and most premature infants due to

- High surface area to body mass ratio
- Immature, water-permeable skin



Concept of a geometric model for estimating insensible water loss in extremely low birth weight infants, using a metabolic balance for the continuous measurement of body weight loss over a 90-minute period. Baumgart S, et. al: Fluid, electrolyte and glucose maintenance in the very low birthweight infant. *Clin Pediatr.*

Ågren et al. suggest that the typical total fluid intake for extremely preterm infants in a humidified incubator start at roughly 100-170 ml/kg/day, assuming IWL is approximately 60-90 ml/kg/day; and urine output is 60-100 ml/kg/day (or at least ≥ 1 ml/kg/hr after the first 24 hours).

Fluid balance among extremely preterm infants should also be evaluated daily due to their unique physiology and extracellular fluid shifts. The loss of extracellular fluid is crucial and driven by natriuresis and a negative fluid balance. Starr et al. suggest that fluid overload in the first 2 weeks of age may have an increased risk of poor respiratory outcomes.

At our center, daily weights are not typically obtained until DOL 4. Additionally, our incubator humidity has increased in recent years to reflect goals of 80 – 85% in first 72 hours of age, 70 – 80% by DOL 4, 60 – 70% by DOL 5, and 50% by DOL 6-7. It is worth mentioning that increased incubator humidity leads to delayed skin maturation and increased TEWL. Fluid requirements should therefore be adjusted accordingly.

Recommendations:

On DOL 0, the starting TFG for infants born < 24 weeks' gestation should be 120–130 ml/kg/day. For infants born at 24–27 weeks' gestation, the starting TFG should be 100 ml/kg/day. Subsequently, consider advancing the total fluid goal by 10 – 20 ml/kg/day if:

- Absence of edema on clinical assessment/physical exam
- Maintain serum sodium ranges between 135 – 145 mmol/L
- Urine output is > 1 ml/kg/hr (after the first 24 hours)

Daily total fluid goals can either be maintained for an additional 24 hours, or advanced more than once in a 24-hour period based on available weights/weight trends, serum sodium values, and urine output.

Total fluid intake should be the sum-total of all IV fluids, including all dextrose- and sodium-containing fluids, total parenteral nutrition, pressors, antibiotics, and flushes. However, blood products should be excluded.

Considerations for Early Hypernatremia:

A rise in sodium and/or chloride among extremely preterm infants in the first several days of age is often a sign of impending dehydration and a need for increased water intake. A serum sodium > 145 mmol/L in this population is concerning and should prompt an increase in total fluid intake. To facilitate adjustments in water or dextrose intake, consider monitoring serum sodium values every 8 – 12 hours in the first 5 – 7 days of age. Ordering 0.45% NS flushes to reduce sodium intake in the first week of age may also be helpful.

Ideal serum sodium levels should be 135 – 145 mmol/L. If serum sodium increases dramatically (> 5 mmol/L), the total fluid goal may need to increase by up to 40 ml/kg/day.

Consider maintaining or increasing TFG if serum sodium levels remain ≥ 145 mmol/L. Consider decreasing the TFG if serum sodium levels fall below 135 mmol/L.

Considerations for Nutrition:
Extremely preterm infants born less than 1,000 grams may have difficulty tolerating trophic feeds in the first few days of age. It may be worthwhile to consider adding or counting feeds in the TFG once feeds have reached > 20 ml/kg/day.

Additionally, use of an amino acid (3% TrophAmine) infusion via the umbilical artery catheter (if present) can reduce the risk of non-oliguric hyperkalemia that occurs among extremely preterm infants during intracellular to extracellular potassium shifts. Though it should be noted that starting or switching to a NaAcetate infusion is equally valuable, especially among those small babies with significant metabolic acidosis in the first several hours to days of age. With either of these infusions, careful calculation of protein load and/or sodium intake are prudent.

Considerations for Early Hyperglycemia:
With an increase in total fluids comes a higher glucose infusion rate (GIR). A higher GIR poses a greater risk of hyperglycemia among extremely preterm infants. Hyperglycemia in these infants typically resolves by 2 – 4 weeks of age, likely because infants have improved insulin secretion versus their initial less effective proinsulin secretion over time.

Limited data show an association between hyperglycemia and long-term adverse effects on growth, neurodevelopment, and cardiovascular and metabolic health. Importantly, hyperglycemia is also associated with increased mortality and morbidity among extremely preterm infants.

At our center, an ideal GIR among extremely preterm infants is typically between 4.5 – 6 mg/kg/min. However, if glucose concentrations are greater than 150 mg/dL, **the first option should be to consider decreasing GIR**. It should be noted that some tiny baby centers of excellence consider reducing GIRs to a value < 2 mg/kg/min to avoid hyperglycemia. Though a decreased GIR for prolonged periods of time may lead to calorie-deficit. Please confer with our NICU nutrition and NICU pharmacy teams to adjust fortification or IV fluids accordingly if there are concerns for calorie deficits.

There should also be consideration for adding a lower dextrose concentration fluid to help decrease the GIR. **If blood glucose levels are persistently > 200 mg/dL despite attempts to decrease the GIR, consider initial insulin boluses (up to 3) at 0.1 units/kg given IV push. If hyperglycemia persists, administration of an insulin drip at 0.01-0.03 units/kg/hr should follow.** Keep in mind that you will need to deliver an initial bolus when starting the infusion just to get the insulin to the end of the infusion catheter and ultimately to baby.

Heparin Correction for Intravenous (IV) Fluids

The usual heparin concentration for patency of fluids via IV catheters in our NICUs is 0.5 units/ml. We should be mindful of the added heparin once IV fluid administration exceeds 150 ml/kg/day. For that reason, it may be best to consider making the primary infusing solution (e.g. starter TPN or custom TPN), the only fluid with added heparin. If the primary infusing fluid runs at a rate greater than 150 ml/kg/day, then the heparin concentration should be decreased to 0.25 units/kg/hr. However, this is not possible for the starter PN solution since it is premade. All other fluids can have the heparin concentration either decreased or removed. Piggyback fluids should especially avoid added heparin.

TFG Volume (ml/kg/day)	Heparin (units/kg/day)	Heparin (units/kg/hour)
100	50	2.1
150	75	3.1
200	100	4.2
250	125	5.2
300	150	6.3

Heparin Dosing. Pediatric and Neonatal Lexi-Drugs, UpToDate Lexidrug.

*****Note: dosing for therapeutic heparin administration (for reference)*****

Systemic heparinization | IV | Initial loading dose: 75 units/kg over 10 minutes; then initial continuous maintenance infusion at 28 units/kg/hour.

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******Appendix A: Examples of Daily Fluid Advancement******

Infants < 24 wks GA or ≤ 500g		
DOL	Total Fluid Goal	Incubator Humidity
0 – 1	120 – 130 ml/kg/day	80 – 85%
2	130 – 140 ml/kg/day	80 – 85%
3	140 – 150 ml/kg/day	80 – 85%
4	150 – 160 ml/kg/day	70 – 80%
5	160 – 180 ml/kg/day	60 – 70%
6 – 7	180 – 200 ml/kg/day*	50%

Infants 24 – 27 wks GA or ≤ 1000g		
DOL	Total Fluid Goal	Incubator Humidity
0 – 1	100 – 110 ml/kg/day	80 – 85%
2	110 – 120 ml/kg/day	80 – 85%
3	120 – 130 ml/kg/day	80 – 85%
4	130 – 140 ml/kg/day	70 – 80%
5	140 – 160 ml/kg/day	60 – 70%
6 – 7	160 – 180 ml/kg/day*	50%

*****The fluid requirements for each small baby are both unique and complex! The tables above should not replace the fluid recommendations outlined on page 2. The tables above also do not mandate that each extremely preterm infant born < 28 weeks' gestation reach TFGs of up to 180 –200 ml/kg/day by DOL 7.*****