

A close-up photograph of a newborn baby's face and hands. The baby's mouth is slightly open, showing its teeth. A clear plastic medical device, possibly a nasal cannula or a small oxygenator, is attached to the baby's nose. The device has a blue band and a white tube. The baby's hands are visible, with fingers slightly curled. The background is blurred, showing a person's face and hands, suggesting a clinical or hospital setting.

# ACORN

Acute Care of **at-Risk** Newborns

2nd Edition

# Fluid and Glucose

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## Educational objectives Upon completion of this chapter, you will be able to:

- • **Identify** infants needing fluid and glucose stabilization.
- • Understand the **principles of fluid and glucose management** in early transition.
- • **Apply** the Acute Care of at-Risk Newborns (**ACoRN**) Fluid and Glucose

### Management Sequence.

- • Recognize and manage infants with, or **at risk** for, hypoglycemia.
- • **Supplement feeds** in infants with early transitional hypoglycemia.
- • **Calculate** and **manage** glucose intake (enterally and/or intravenously) to stabilize hypoglycemia.

- • Recognize infants who require intravenous **(IV)** fluids.
- • Recognize infants whose hypoglycemia is unlikely to **resolve quickly**, who may need **consultation** and/or transfer to a **higher level** of care.
- • Recognize infants with **persistent** or **refractory** hypoglycemia, who need **medication** to assist counter-regulation or block insulin release.
- • Recognize **when to exit** the Fluid and Glucose Sequence to other ACoRN sequences.

# Skills

- Calculation of GIR

## Fluid requirements in infants

In assessing fluid status, consider the following types of fluid requirements:

- **Maintenance** fluids
- Intravascular volume expanders (to replace **deficit**)
- Replacement of excessive or **ongoing losses**

# Maintenance Fluids

- The fluid requirement for most infants on day 1 of life is approximately  $3 \text{ mL/kg/h}$  but

may be as high as  $4 \text{ mL/kg/h}$  in an extremely premature infant being cared for under a radiant warmer, due to insensible water loss.

Because free water excretion is limited during the normal prediuretic phase of neonatal transition, fluid volumes exceeding  $4 \text{ mL/kg/h}$  should not be administered before an infant is 24 to 48 h old.

- Infants with **renal dysfunction** resulting in lower urine output may not be able to tolerate intake rates over **2 mL/kg/h**.
- For infants with **oliguria** (defined as urine output less than **1 mL/kg/h after 24 h of age**) the glucose in fluid infusions may need to be concentrated such that the hourly rate of fluid administered will not exceed the maximum tolerance for day of age and condition



- When the infant's **diuretic phase** is established, a fluid intake of **6 mL/kg/h** is both tolerated and needed to deliver nutrients and meet growth demands.
- For infants receiving **IV fluids, electrolytes** are added on or **after day 2 of age**, when urine output has become established and electrolyte status has been assessed
- For infants with hypoxic ischemic encephalopathy (**HIE**) and/or **oliguria**, initial volumes should not **exceed 2 mL/kg/h**.

# Intravascular volume expanders

- Unwell infants with intravascular volume contraction present with **hypotension**, **hypoperfusion**, or **shock**.
- They need an **isotonic** intravascular volume expander to replace deficit. **The solution of choice is 0.9% NaCl** (normal saline)
- Fluid loss volumes can be difficult to estimate but are best assessed by the **infant's response** to administered bolus of 10 mL/kg/min over 10 to 20 min.

# Replacement of excessive or ongoing losses

- Unwell infants may need volume replacement for excessive or ongoing losses
- Examples include evaporative loss from an open lesion (e.g., gastroschisis), gastric or enteric fluid loss, or excessive diuresis
- Excess or ongoing fluid losses should be replaced using an IV solution that is similar in electrolyte content to the fluid lost, usually 0.9% NaCl or 0.45% NaCl, with or without potassium chloride
- . Replacement of excessive or ongoing losses should be in addition to routine maintenance fluids or volume expanders.

Volume expansion, replacement of ongoing losses, and maintenance fluid requirements must each be charted separately on a fluid balance sheet, along with urine output and other measurable losses (in mL/kg/h units)

# Glucose requirement and homeostasis

Glucose is the **main source** of energy for brain cells.

**Neurologic compromise** can occur if the brain is deprived of glucose.

**Blood glucose concentration** is determined by the rate of **endogenous glucose production** plus the **rate of exogenous(external)glucose administration**, minus the rate of **glucose utilization**

- **Well term infants** who are breastfeeding during transition have a glucose intake of approximately **1 to 2 mg/kg/min**, derived from lactose. Their intake is well below their baseline glucose utilization rate of **4 to 6 mg/kg/min**.

- Premature infants have bigger brains relative to their body size.

Both premature and stressed infants have higher metabolic rates. Their baseline glucose utilization rate is slightly higher, at 5 to 7 mg/kg/min

- Hypoglycemia can be **asymptomatic** or **symptomatic**. Infants who are symptomatic enter the ACoRN Neurology Sequence first and receive immediate IV dextrose.



# Signs of hypoglycemia in the neonate include:

- Intermittent **apneic** spells or **tachypnea**
- Episodes of **cyanosis**
- Cardiac **failure**
- Sudden **pallor**
- Abnormal **tone** (limpness)
- Abnormal level of **alertness** (lethargy)
- Abnormal **movements** (jitteriness or tremors)
- **Seizure-like** movements
- **Weak** or **high-pitched** crying
- **Difficulty** feeding
- Sweating
- Hypothermia

- Symptomatic or persistent hypoglycemia is a medical emergency and requires immediate treatment with an IV dextrose solution.

Follow-up of subsequent blood glucose samples and further clinical investigation are imperative.

# At risk for hypoglycemia

- Are small for gestational age (**SGA**; weigh less than 10th percentile),
- Have **IUGR**,
- Are **LGA** (weigh greater than 90th percentile),
- Are **IDMs** born to mothers with **gestational** or **insulin-dependent** diabetes,
- Are **premature** (including **late preterm**), or
- Experience **perinatal stress** or **hypoxemia**,

## Screen for hypoglycemia with the following risk factors in mind:

- **SGA** infants, and especially those who also have **IUGR**, are at high risk for developing new or recurrent

hypoglycemia, with onset up to **24 h** post-birth.

- About 8% of **LGA** infants experience transient hypoglycemia, with onset in the first **12 h**.
- **IDMs** may have transient hyperinsulinism, a condition which is present at birth and usually resolves within 3 to 7 days. Transient hyperinsulinism can limit a newborn's ability to initiate gluconeogenesis and make ketones. Blood glucose levels decline more abruptly in IDMs than in typical infants, with the lowest point occurring at 1 to 2 h of age. Onset of hypoglycemia is unlikely to occur beyond 12 h post-birth. IDMs who are also LGA have an even higher risk for developing hypoglycemia.

- While also at risk for transient hypoglycemia, **late preterm** infants who are feeding well are unlikely to develop the condition beyond 12 h post-birth.

## Screening recommendations:

- Glucose screening at **2 h** of age is indicated for **well term** and **late preterm** infants **at risk** for hypoglycemia. These infants should be **breastfed** or fed on cue as early as possible after birth and before their first glucose check.
- Glucose screening **on admission** is indicated for **preterm** infants (less than 35 weeks GA) and all infants who are **unwell**, **cannot feed**, or **should not** be fed for clinical reasons.

Infants who are not feeding, or should not be fed because they are unwell, require IV fluids and glucose. These include infants with:

- Moderate to severe respiratory distress,
- Cardiovascular instability (shock, cyanosis, or tachyarrhythmia),
- Symptomatic hypoglycemia,
- Neonatal encephalopathy or an Apgar score of 3 or less at 5 min,
- Poor airway protection, seizures, and/ or abnormal tone,
- Surgical conditions (e.g., gastroschisis, omphalocele, tracheoesophageal fistula),
- Abdominal distension, vomiting, gross blood in stool (except when due to swallowed maternal blood), or
- Sepsis.

## Guidelines for intake by age in infants requiring measured feeds or IV fluids

Age	Measured feeds (if not breastfeeding on cue)	IV fluids
Day 1	Up to 6 mL/kg q 2 h or 9 mL/kg q 3 h	3 mL/kg/h
Day 2	Up to 8 mL/kg q 2 h or 12 mL/kg q 3 h	4 mL/kg/h
Day 3	Up to 10 mL/kg q 2 h or 15 mL/kg q 3 h	5 mL/kg/h
≥ Day 4	Up to 12 mL/kg q 2 h or 18 mL/kg q 3 h	6 mL/kg/h

Important information to gather for fluid and glucose management includes the following

## Antepartum

- • Maternal **diabetes**
- • Maternal **infection**
- • Maternal **medications**
- (e.g., beta blockers, steroids, or oral hypoglycemics)



## Intrapartum

- **Excessive** maternal glucose infusion during labour (greater than **100 mL/h** of D10W)
- **Abnormal** fetal heart rate

# Neonatal

- Umbilical cord **pH less than 7.0**
- Extent of **resuscitation** efforts at birth
- Apgar score equal to or less than **3 at 5 min**
- Prematurity
- Need for **intensive** or **transitional** care
- Birth weight and classification as **AGA**, **SGA**, or **LGA**
- **Difficulty** feeding or **unable** to feed
- Suspected or proven **infection**
- **Seizures**, **jitteriness**, **irritability**, or **lethargy**
- Number of **wet diapers**/day
- Passage of **meconium**

# Observation

- Current **weight** compared with birth weight and previously documented weight
- Skin **colour** for jaundice or plethoric appearance
- Surgical conditions or congenital anomalies
- Respiratory effort
- Measurement of **vital signs**: temperature, respiratory rate, heart rate, and blood pressure

# Examination

- Signs of **dehydration**—dry mucosa, and/or poor skin turgor with tenting, sunken fontane
- **Neurologic status**—level of activity, jitteriness, irritability, or seizures
- Signs of **circulatory** instability
- Feeding **readiness** (ability and intensity of suck-swallow and level of energy)
- **Abdominal** distension, tenderness, or bowel sounds

The diagnosis of hypoglycemia can be categorized as:

- **Transitional**, responding to supplementation with dextrose gel or measured feeding volumes,
- **Transitional**, requiring **IV** therapy (GIR less than 8) for less than 72 h post-birth,
- **Persistent** or **recurrent**, requiring active management past 72 h post-birth (GIR greater than 8), or
- **Refractory**, persistent despite escalation of IV dextrose.

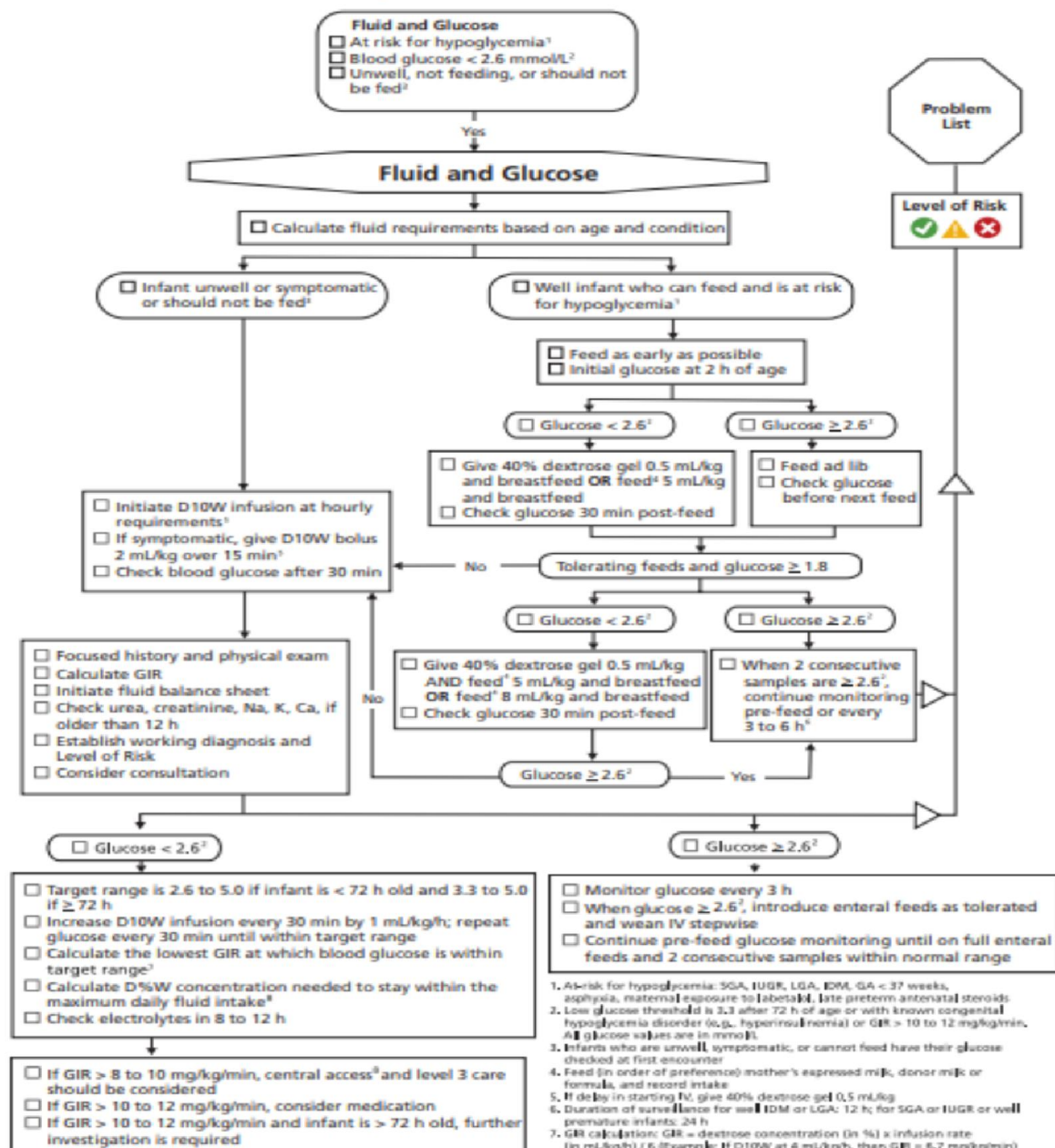
# Alerting Signs

- An infant who shows **one or more** of the following Alerting Signs enters the **ACoRN Fluid and Glucose Sequence**.

## Fluid and Glucose

- ☐ At risk for hypoglycemia<sup>1</sup>
- ☐ Blood glucose < 2.6 mmol/L<sup>2</sup>
- ☐ Unwell, not feeding, or should not be fed<sup>3</sup>

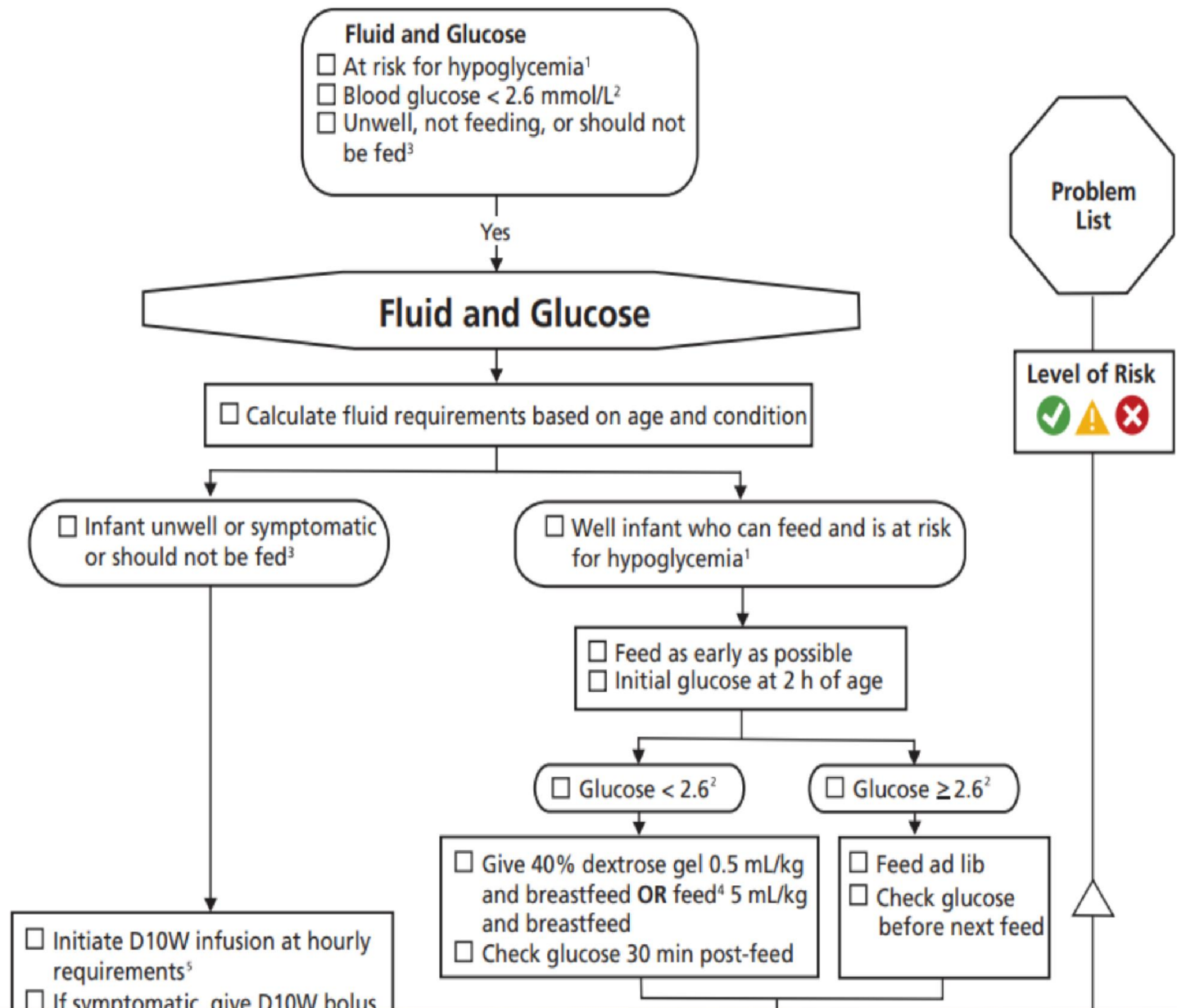
# ACoRN Fluid and Glucose Sequence



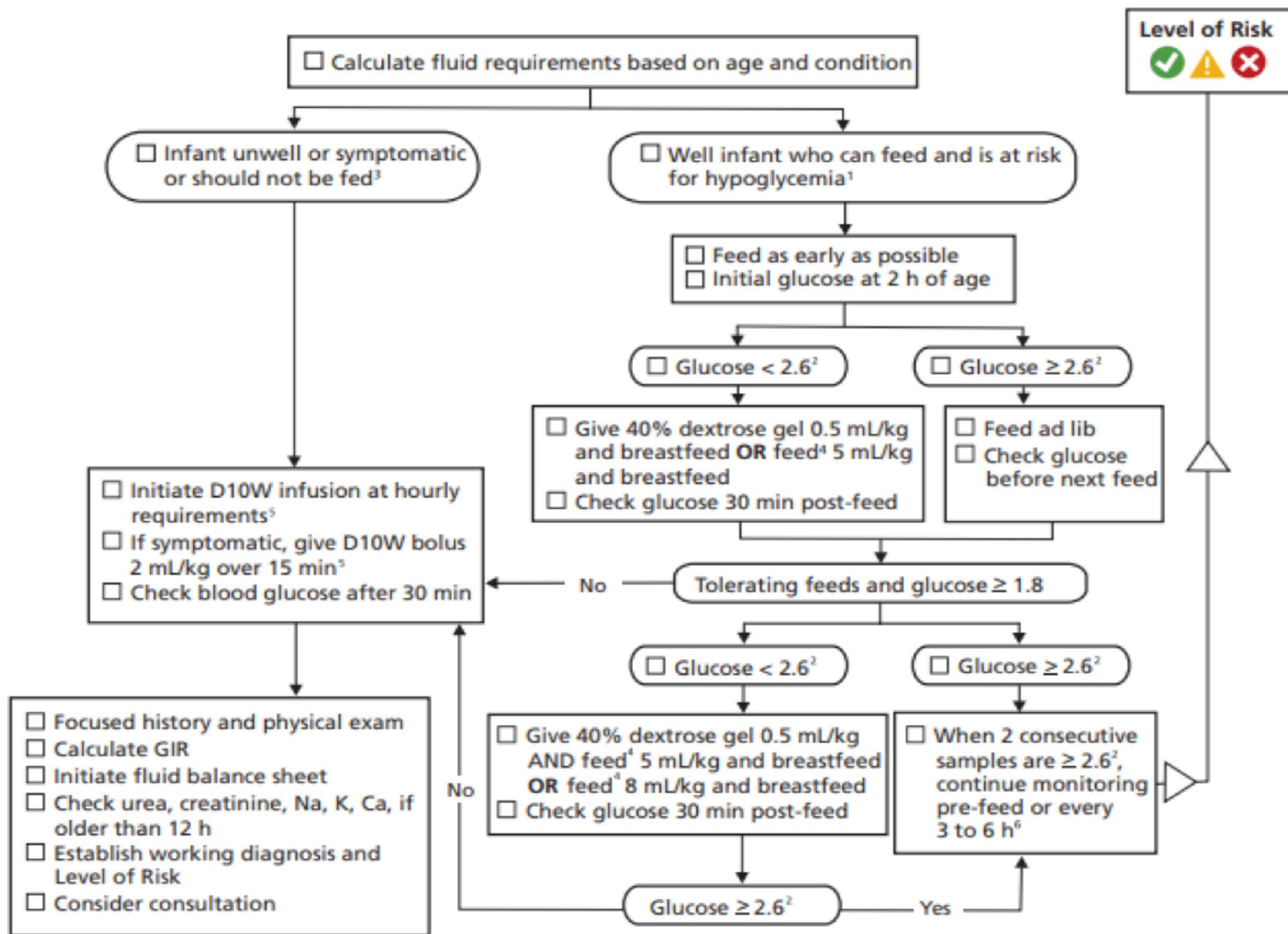
Abbreviations: Ca - calcium, D%W - %age dextrose in water (e.g., D10W = dextrose 10% in water), GA - gestational age, GIR - glucose infusion rate, h - hours, IDM - infants of diabetic mothers, IUGR - intrauterine growth restriction, IV - intravenous, K - potassium, LGA - large for gestational age, min - minutes, Na - sodium, SGA - small for gestational age

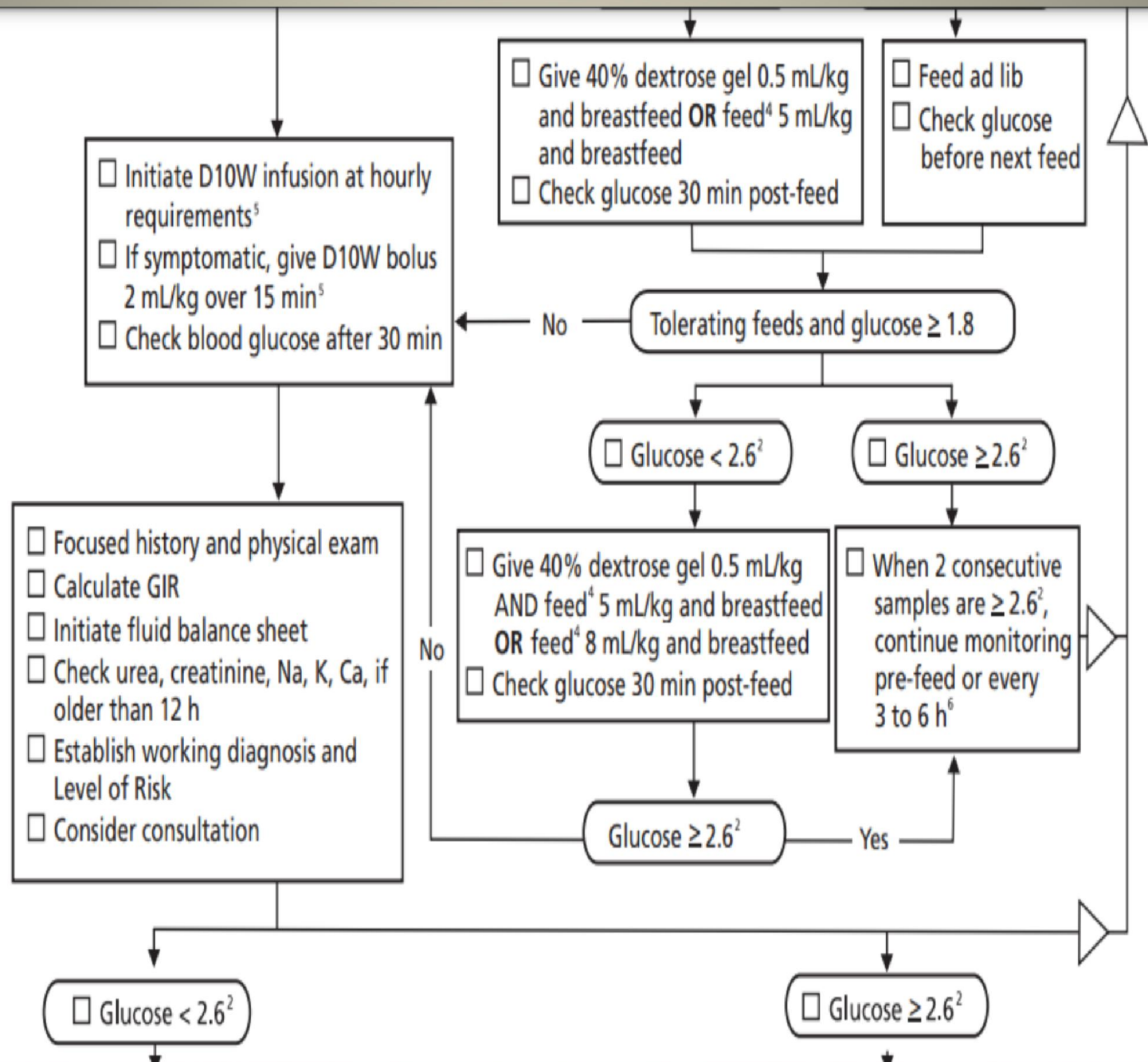
- At-risk for hypoglycemia: SGA, IUGR, LGA, IDM, GA < 37 weeks, asphyxia, maternal exposure to diabetes, late preterm antenatal steroids
- Low glucose threshold is 3.3 after 72 h of age or with known congenital hypoglycemia disorder (e.g., hyperinsulinemia) or GIR > 10 to 12 mg/kg/min. All glucose values are in mmol/L
- Infants who are unwell, symptomatic, or cannot feed have their glucose checked at first encounter
- Feed (in order of preference) mother's expressed milk, donor milk or formula, and record intake
- If delay in starting IV, give 40% dextrose gel 0.5 mL/kg
- Duration of surveillance for well IDM or LGA: 12 h; for SGA or IUGR or well premature infants: 24 h
- GIR calculation: GIR = dextrose concentration (in %) x infusion rate (in mL/kg/h) / 6 (Example: If D10W at 4 mL/kg/h, then GIR = 6.7 mg/kg/min)
- Can give up to D20W by peripheral IV until central access is obtained

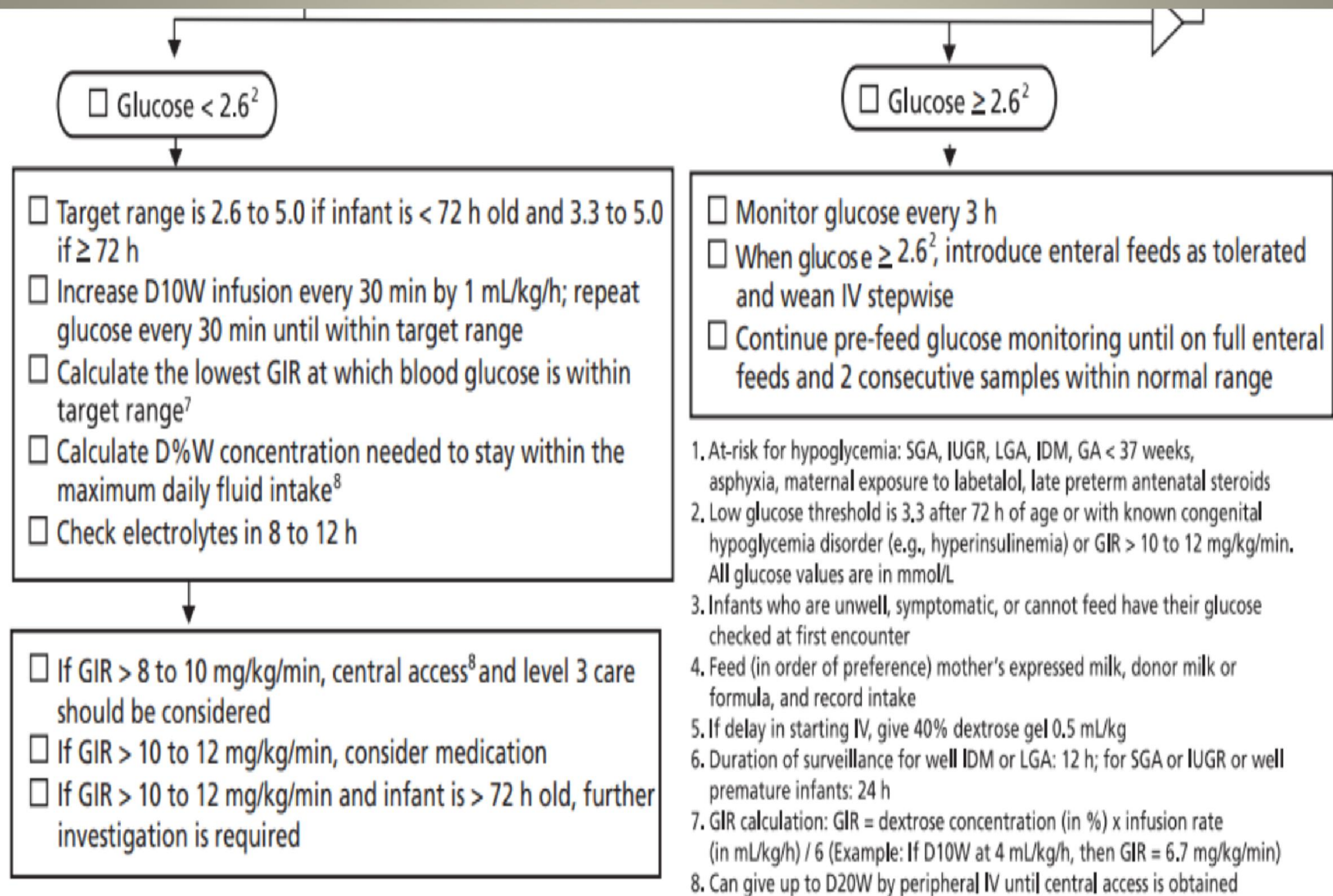
## ACoRN Fluid and Glucose Sequence











Abbreviations: Ca - calcium, D%W - %age dextrose in water (e.g., D10W = dextrose 10% in water), GA - gestational age, GIR - glucose infusion rate, h - hours, IDM - infants of diabetic mothers, IUGR - intrauterine growth restriction, IV - intravenous, K - potassium, LGA - large for gestational age, min - minutes, Na - sodium, SGA - small for gestational age



## **GIR: Examples and insights**

- The GIR of a 1-day-old infant needing D10W at 3 mL/kg/h for hypoglycemia is:

$$\text{D10 W at 3 mL/kg/h} \rightarrow \text{GIR} = 10 \times 3 / 6 \rightarrow \text{GIR} = 5.0 \text{ mg/kg/min.}$$

This infant's glucose requirements are within normal limits (4 to 6 mg/kg/min). The need for active glucose management will likely resolve within 24 to 48 h.

- The GIR of a 1-day-old infant requiring D10W at 4 mL/kg/h for hypoglycemia is:

$$\text{D10 W at 4 mL/kg/h} \rightarrow \text{GIR} = 10 \times 4 / 6 \rightarrow \text{GIR} = 6.7 \text{ mg/kg/min.}$$

This infant's glucose requirement is slightly elevated. The need for active glucose management will likely continue for a few days.

- The GIR of a 1-day-old infant requiring D15W at 4 mL/kg/h for hypoglycemia is:

$$\text{D15 W at 4 mL/kg/h} \rightarrow \text{GIR} = 15 \times 4 / 6 \rightarrow \text{GIR} = 10 \text{ mg/kg/min.}$$

This infant may need medication in addition to high concentration dextrose, and should be evaluated for persistent hypoglycemia if increased GIR persists past 72 h or if hypoglycemia recurs. Hospital stay is likely to exceed 1 week.

## Level of Risk: Fluid and Glucose

In the ACoRN Fluid and Glucose Sequence, level of risk is based on: whether the infant is well and can feed or unwell and cannot feed, blood glucose levels and their response to management, the treatment intensity required, and the presence or absence of neurological signs associated with hypoglycemia.



### Green:

- Infant is well and feeding
- Blood glucose is within target range for age
- Blood glucose is within target range in response to 40% dextrose gel and/or measured feeds



### Yellow:

- A D10W infusion is needed because the infant is unwell and cannot feed
- A D10W infusion is needed to maintain blood glucose within recommended target, with a GIR less than 8 mg/kg/minute

Infants at a Yellow Level of Risk require increased levels of attention and consultation. Transfer is required if needs exceed site capabilities.



### Red:

- Minimum GIR required to maintain blood glucose within target is greater than 8 mg/kg/minute
- Neurologic signs are present that may be associated with hypoglycemia

Infants at Red Level of Risk require level 3 care. Transfer is required if needs exceed site capabilities.

# Key concepts

- 1. **Healthy term** infants without risk factors for hypoglycemia should **breastfeed** on cue soon after birth. They do not need fluid supplements, investigation, or screening for hypoglycemia.
- 2. **Well term** and **late preterm** infants with risk factors for hypoglycemia who can be fed, should breastfeed on cue as soon as possible after birth and before the first glucose check at 2 h of age.
- 3. **Unwell** infants and those who **cannot feed** require IV fluids and glucose to maintain normal water balance and energy supply.

- 4. **Water** and **electrolyte** balance should be carefully monitored in infants receiving IV fluids.
- 5. **Reliable** and **accurate** blood glucose screening is essential in all institutions caring for infants. If point-of-care devices are used, appropriate quality control measures should be in place.
- 6. Glucose infusion rates (**GIRs**) greater than **8 mg/kg/min** indicate need for higher level care. More invasive or intensive management may be required.
- 7. Hypoglycemia, dehydration, and overhydration can cause **short-** and **long-term** complications.



