Hypoglycaemia–newborn
Well, at risk newborn baby (first 48 hours of life)
If baby is symptomatic for hypoglycaemia or screening BGL < 2.6 mmol/L—refer to Flowchart: Management of hypoglycaemic newborn baby

Risk factors for hypoglycaemia
- Temperature < 36.5 °C or labile
- Baby of woman with diabetes
- Preterm < 37 weeks gestation
- Inadequate feeding
- SGA < 10th centile
- LBW < 2500 g
- LGA > 90th centile
- Resuscitation at birth
- Post-mature baby > 42 weeks gestation
- Polyhydramnios
- Macrosomia
- Macrocephaly
- Suspected syndromes
- Maternal medications—beta blockers; dexamethasone; oral hypoglycaemics
- Family history of metabolic and/or endocrine disorders

At birth
- Assess for risk factors
- Keep baby warm
  - Dry baby
  - Early skin-to-skin
  - Maintain temperature 36.5 °C–37.5 °C
- Initiate feeds within 30–60 minutes of birth
  - Discuss feeding cues
  - Feed at least 3 hourly or more frequently
  - Gavage feed if baby < 35 weeks
- Keep mother and baby together if possible
  - Discuss preventative care with parents

Symptomatic or unwell baby
May have one or more signs
- Poor feeding
- Tremors/jitteriness
- Apnoea
- Cyanosis
- Irregular, rapid breathing
- Seizures
- Altered LOC—irritability, lethargy, stupor, coma
- Hypotonia
- Weak or high pitched cry

Effective 1st feed?
- Yes
- No

Symptomatic or unwell or BGL < 1.5 mmol/L?
- Yes
- No

BGL ≥ 2.6 mmol/L?
- Yes
- No

BGL 1.5–2.5 mmol/L?
- Yes
- No

Confirm any BGL < 2.6 mmol/L in blood gas machine, PoC analyser or laboratory
- If indicated/possible give glucose gel 40% and feed baby
- Medical/NNP review
  - Consider neonatologist consultation
  - Admit to neonatal unit
  - Refer to Flowchart: Initial management of hypoglycaemia in newborn baby—symptomatic or BGL < 1.5 mmol/L (first 48 hours of life)

BGL, blood glucose level; EBM, expressed breast milk; IV, intravenous; LBW, low birth weight; LGA, large for gestational age, LOC, level of consciousness, NNP, neonatal nurse practitioner; RSQ, Retrieval Services Queensland; SGA, small for gestational age, < less than, > greater than, ≥ greater than or equal to

Flowchart: F19.8-1-V9-R24
Initial management of hypoglycaemic newborn baby (first 48 hours of life)

BGL 1.5–2.5 mmol/L?

Yes

- If baby well and ≥ 35 weeks gestation–give glucose gel 40% 0.5 mL/kg buccally prior to feed
  - Criteria: Maximum 2 doses in succession up to 6 doses in total in 1st 48 hours
- Feed immediately:
  - If baby’s condition allows give breast feed
  - If required give oral/enteral EBM (if available) or formula or combination at 60 mL/kg/ day
- Notify medical officer/NNP
- Repeat BGL 30 minutes after glucose gel 40%

No

BGL < 1.5 or unrecordable or symptomatic baby?

Yes

If consent for formula withheld:
- Discuss benefits and risks of formula versus hypoglycaemia outcomes
- Consider IV glucose

No

BGL ≥ 2.6 mmol/L and meets glucose gel 40% criteria?

Yes

Notify medical officer/NNP

Admit to neonatal unit–if required contact RSQ

Refer to Flowchart: Initial management of hypoglycaemia in newborn baby–symptomatic or BGL < 1.5 mmol/L (first 48 hours of life)

No

2 doses glucose gel 40% with feed or BGL < 2 mmol/L?

Yes

BGL ≥ 2.6 mmol/L?

Yes

- Continue usual care
- Cease BGL monitoring if:
  - BGL ≥ 2.6 mmol/L for 24 hours in 1st 48 hours or ≥ 3.3 mmol/L after 48 hours
  - Baby feeding effectively–if term baby, enteral feeding discontinued
  - Baby is well and has not required IV glucose
- If known/suspected hypoglycaemic disorder:
  - Continue BGL monitoring and maintain ≥ 4 mmol/L and
  - Do 6 hour fast test
- Discharge and follow-up
  - As per underlying cause
  - May require long-term follow-up
  - May require 6 hour fast test prior to discharge

No

BGL 1.5–2.5 mmol/L?

Yes

- If baby well and ≥ 35 weeks gestation–give glucose gel 40% 0.5 mL/kg buccally prior to feed
  - Criteria: Maximum 2 doses in succession up to 6 doses in total in 1st 48 hours
- Feed immediately:
  - If baby’s condition allows give breast feed
  - If required give oral/enteral EBM (if available) or formula or combination at 60 mL/kg/ day
- Notify medical officer/NNP
- Repeat BGL 30 minutes after glucose gel 40%

No

Monitor BGL 4–6 hourly pre-feed for 1st 24–48 hours

BGL ≥ 2.6 mmol/L?

Yes

- Continue usual care
- Cease BGL monitoring if:
  - BGL ≥ 2.6 mmol/L for 24 hours in 1st 48 hours or ≥ 3.3 mmol/L after 48 hours
  - Baby feeding effectively–if term baby, enteral feeding discontinued
  - Baby is well and has not required IV glucose
- If known/suspected hypoglycaemic disorder:
  - Continue BGL monitoring and maintain ≥ 4 mmol/L and
  - Do 6 hour fast test
- Discharge and follow-up
  - As per underlying cause
  - May require long-term follow-up
  - May require 6 hour fast test prior to discharge

No

Confirm any BGL < 2.6 mmol/L in blood gas machine, PoC analyser or laboratory

Glucose gel 40% (0.5 mL/kg)

<table>
<thead>
<tr>
<th>Baby’s weight</th>
<th>Volume to be administered</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000–2080 g</td>
<td>1 mL</td>
</tr>
<tr>
<td>2081–2280 g</td>
<td>1.1 mL</td>
</tr>
<tr>
<td>2281–2480 g</td>
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<tr>
<td>2481–2680 g</td>
<td>1.3 mL</td>
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<td>2681–2880 g</td>
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<td>1.9 mL</td>
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<tr>
<td>4081–4280 g</td>
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<tr>
<td>4281–4480 g</td>
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</tr>
<tr>
<td>4481–4680 g</td>
<td>2.3 mL</td>
</tr>
<tr>
<td>4681–4880 g</td>
<td>2.4 mL</td>
</tr>
<tr>
<td>4881–5080 g</td>
<td>2.5 mL</td>
</tr>
</tbody>
</table>

BGL blood glucose level, EBM expressed breast milk, IV intravenous, NNP neonatal nurse practitioner, < less than, ≥ greater than or equal to

Flowchart: F19.8-2-V6-R24
Flow Chart: Management of BGL less than 1.5 mmol/L or baby symptomatic

BGL ≥ 3.0 mmol/L for > 12 hours?

No

IV glucose ≥ 8 mg/kg/min or Baby > 48 hours of age or BGL refractory or requires medication to control?

No

Consult with neonatologist via RSQ

Discuss pharmacological intervention

Refer to NeoMedQ for doses and other information

Yes

Glucose mg/kg/minute

<table>
<thead>
<tr>
<th>%</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>4.2</td>
<td>5.6</td>
<td>6.9</td>
<td>8.3</td>
</tr>
<tr>
<td>12%</td>
<td>5</td>
<td>6.7</td>
<td>8.3</td>
<td>10</td>
</tr>
<tr>
<td>14%</td>
<td>5.8</td>
<td>7.8</td>
<td>9.7</td>
<td>11.7</td>
</tr>
<tr>
<td>16%</td>
<td>6.7</td>
<td>8.9</td>
<td>11.1</td>
<td>13.3</td>
</tr>
<tr>
<td>18%</td>
<td>7.5</td>
<td>10</td>
<td>12.5</td>
<td>15</td>
</tr>
<tr>
<td>20%</td>
<td>8.3</td>
<td>11</td>
<td>13.9</td>
<td>16.7</td>
</tr>
</tbody>
</table>

Glucose infusion rate (GIR) in ml/kg/day

Glucose mg/kg/minute

Blood gas—during hypoglycaemic episode

- Insulin
- Cortisol
- Acyl-carnitine profile

Urine—post-hypoglycaemic episode

- Plasma amino acids
- Ammonium
- Pyruvate
- Beta hydroxybutyrate

Priority 1 Insulin

Priority 2 Growth hormone

Priority 3 Plasma amino acids

Markers of metabolic acidosis

- Acetate
- Beta-hydroxybutyrate

BGL blood glucose level, CVL central venous line, GIR glucose infusion rate, IM intramuscular, IV intravenous, NNP neonatal nurse practitioner, PoC point of care, RSQ Retrieval Services Queensland, subcut subcutaneous, UVC umbilical venous catheter, > greater than, < less than, ≥ greater than or equal to.
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Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL</td>
<td>Blood glucose level</td>
</tr>
<tr>
<td>EBM</td>
<td>Expressed breast milk</td>
</tr>
<tr>
<td>FGR</td>
<td>Fetal growth restriction</td>
</tr>
<tr>
<td>GIR</td>
<td>Glucose infusion rate</td>
</tr>
<tr>
<td>IM</td>
<td>Intramuscular</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
</tr>
<tr>
<td>LCHAD</td>
<td>Long-chain 3-hydroxyacyl-CoA dehydrogenase deficiency</td>
</tr>
<tr>
<td>LGA</td>
<td>Large for gestational age (consider parental ethnicity and anthropometry)</td>
</tr>
<tr>
<td>MCADD</td>
<td>Medium chain acyl-CoA dehydrogenase deficiency</td>
</tr>
<tr>
<td>NICU</td>
<td>Neonatal intensive care unit</td>
</tr>
<tr>
<td>NNP</td>
<td>Neonatal nurse practitioner</td>
</tr>
<tr>
<td>PICC</td>
<td>Peripherally inserted catheter</td>
</tr>
<tr>
<td>RSQ</td>
<td>Retrieval Services Queensland</td>
</tr>
<tr>
<td>SGA</td>
<td>Small for gestational age (consider parental ethnicity and anthropometry)</td>
</tr>
<tr>
<td>UVC</td>
<td>Umbilical venous catheter</td>
</tr>
</tbody>
</table>

Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical judgement</td>
<td>The application of practice, experience, knowledge and continuous critical analysis to communication, diagnosis and decision making.¹</td>
</tr>
<tr>
<td>Clinical significance</td>
<td>Conditions that raise higher concern if the blood glucose level (BGL) is borderline or at the lower end of the normal range and may require earlier intervention.</td>
</tr>
<tr>
<td>Enteral feeding</td>
<td>In this guideline includes any method and type of feeding combination (e.g. oro/nasogastric tube, breastfeeding, bottle, breast milk or formula)</td>
</tr>
<tr>
<td>Hypoglycaemia</td>
<td>BGL less than 2.6 mmol/L.</td>
</tr>
<tr>
<td>Hypoglycaemia–prolonged</td>
<td>Lasts longer than 48 hours.</td>
</tr>
<tr>
<td>Hypoglycaemia–recurrent</td>
<td>More than 3 sequential episodes of BGL less than 2.6 mmol/L.</td>
</tr>
<tr>
<td>Hypoglycaemia–severe</td>
<td>BGL less than 1.5 mmol/L or symptomatic.</td>
</tr>
<tr>
<td>Macrosomia</td>
<td>Birth weight greater than the 90th percentile or intrauterine growth beyond 4.5 kg.</td>
</tr>
<tr>
<td>Nadir</td>
<td>The lowest point (e.g. lowest blood glucose level).</td>
</tr>
<tr>
<td>Neonatal Unit</td>
<td>Area for babies requiring care and management ranging from standard newborn care to special or intensive care.² This may be an area of the maternity ward while waiting for Retrieval Services Queensland (RSQ).</td>
</tr>
</tbody>
</table>
1 Introduction

1.1 Normal physiology

During fetal life glucose, lactate and amino acids are the principal sources of energy. The fetus receives glucose from the mother achieving fetal plasma glucose concentrations 70–80% of the maternal level. The fetal insulin level is independent of the mother’s level, as insulin does not cross the placenta, but it is dependent on the fetal blood glucose level. During the last trimester of pregnancy when there is rapid growth, energy stores (particularly glycogen and adipose tissue) are laid down in preparation for birth.3

Blood glucose levels (BGL) in healthy term newborn babies fall in the first two hours of life during transition to extra-uterine life. An asymptomatic, transient and mildly low BGL after birth is normal.4 It occurs due to the transition from continuous transplacental glucose supply from the mother in-utero, to an intermittent supply from milk feeds.

Physiological transition beginning immediately after birth includes—

- Endocrine changes—
  - Plasma insulin levels fall and catecholamines and pancreatic glucagon are released
  - Essential enzymes for the production of glucose from stores of glycogen and fat (glycogenolysis and gluconeogenesis), and the production of free fatty acids (lipolysis) and ketones (ketogenesis) are switched on3
  - Importantly, the production of these enzymes is inhibited by insulin, so persistent high insulin levels prevent this normal adaptation
- Glycogenolysis—production of glucose by the liver when stored glycogen is broken down to form pyruvate in response to increased adrenaline and glucagon concentrations and falling insulin levels3
- Gluconeogenesis—plasma glucose levels are maintained by glucose synthesis from non-carbohydrate sources (e.g. glycerol, lactate, pyruvate and glucogenic amino acid precursors) and occurs during the first 8–12 hours of life when glycogen stores are depleted3,5
- Stimulation of appetite and adaption to fast and feed cycle and promotion of oxidative fat metabolism using lipid from fat stores and milk feeds5
  - Delay in the first feed for 3–6 hours after birth results in approximately 10% of babies not maintaining their plasma glucose levels above 1.7 mmol/L6
  - Concentrations of free fatty acids, lactate and ketones as substrate for metabolism are raised in response to breast feeding

It is generally accepted that the BGL is low in the first six hours of life. However, there is lack of international consensus about the normal range for prefeed plasma glucose in the normal healthy baby during this time period. The nadir usually falls in the first two to four hours of life then, by four to six hours of age stabilises at 2.5–4.4 mmol/L (may be up to 6.2 mmol/L).5 Over subsequent days the mean BGL rises slowly to concentrations seen in older children and adults6, and is generally acceptable if above 3.6 mmol/L without any treatment in place.

Glucose levels in the blood are maintained during post-prandial and post-absorptive states by balancing glucose utilisation with endogenous glucose production. Counter-regulation is the process in the fasted state where the body makes glucose available.3 Due to the disproportionately larger brain size relative to body mass, babies’ glucose utilisation rate (per unit of body mass) is two to three times higher compared with adults.4

This normal physiological transitional response is different from disorders resulting in persistent or recurrent hypoglycaemia.7
### 1.2 Definition

Table 1. Clinical hypoglycaemia

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Context**                   | • A baby’s BGL changes in the first hours after birth  
• Generally, hypoglycaemia is defined as:  
  o Symptomatic baby [refer to Table 6. Clinical signs] and/or  
  o BGL less than 2.6 mmol/L\(^8-10\)  
    ▪ If BGL less than 1.5 mmol/L or unrecordable–hypoglycaemia is severe |
| **Clinical hypoglycaemia**    | • BGL low enough to cause signs of impaired brain function\(^{11}\)  
  o Refer to Table 6. Clinical signs  
  • Not defined based on specific BGL\(^{11}\) as:  
    o Not possible to identify single BGL that causes brain injury  
      ▪ Injury extent influenced by other factors including extent and duration of hypoglycaemia, and availability and baby’s ability to use other substrates such as lactate, fatty acids and ketones  
    o Specific brain response thresholds to hypoglycaemia vary across different BGL |
| **Factors influencing clinical significance** | • Inborn errors of metabolism  
• Hyponatraemia  
• Neonatal encephalopathy  
• Conditions associated with diminished hepatic glucose production\(^{12}\) or increased glucose consumption  
  o Cold stress  
  o Congenital heart disease; congestive heart failure  
  o Intrauterine growth restriction  
  o Prematurity  
  o Perinatal stress/hypoxia  
  o Sepsis/infection |
| **Clinical standards**        | • Screen all at risk babies  
• Avoid separation of mother and baby unless admission to neonatal unit is required for investigation and management  
• Screen baby with glucometer with electrochemical sensor that uses glucose oxidase test strips\(^{13}\)  
• Refer to Queensland Clinical Guideline Standard care\(^{14}\) |
| **Blood sample collection**   | • Use heel prick (do not squeeze poorly perfused heel) or venepuncture for screening  
  • If taking heel prick sample, warm the baby’s heel and discard the first drop of blood to optimise accuracy in glucometer reading  
  • Use venepuncture for diagnostic tests (including BGL when indicated)  
  • Do not take samples from intravenous or intra-arterial lines infusing glucose  
  • Ensure adequate drawback of fluid and blood from indwelling lines administering other solutions, for example sodium chloride 0.9% |
2 Babies at risk

Generally, neonatal hypoglycaemia is caused by one or more of:

- Increased levels of insulin (regulatory hormone)\textsuperscript{3,12,15-18}
- Increased glucose utilisation\textsuperscript{12}
- Inadequate glucose supply\textsuperscript{3,12}
- Inadequate body stores (glycogen, fat)\textsuperscript{18-20}
- Decreased levels of counter-regulatory hormones (e.g. growth hormones, cortisol, adrenergic hormones)\textsuperscript{12,15,17,18}
- Disorders of glycogen metabolism (glycogenolysis)\textsuperscript{12,16,20}
- Disorders of glucose production (gluconeogenesis)\textsuperscript{12,16,19,20}
- Congenital anomalies, or unknown or mixed causes\textsuperscript{3-6,15,16,21,22}

Babies at risk may or may not present with signs of hypoglycaemia [refer to Table 6. Clinical signs]. Consider the number and type of risk factors when planning management for the baby. Extra vigilance is required for babies who have multiple risk factors. These include babies born to women with diabetes mellitus (any type) or if there is a sibling or other family member with a history of a metabolic disorder such as medium chain acyl-CoA dehydrogenase deficiency (MCADD) or an endocrine disorder (e.g. adrenal or pituitary).

Where there is impaired metabolic adaptation there may be impaired glucose and ketone body production. This may be due to various conditions including prematurity, fetal growth restriction, perinatal hypoxia/ischaemia and poorly controlled gestational diabetes mellitus [refer to Table 2. Maternal risk factors and Table 3. Risk factors and causes]. These babies require prevention, diagnosis and management of hypoglycaemia to reduce the risk of harm.\textsuperscript{3}

2.1 Maternal risk factors

Table 2. Maternal risk factors

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| Maternal medications    | • Beta-blockers\textsuperscript{6,23} (aOR 1.68, 95% CI 1.50 to1.89)\textsuperscript{23}, (e.g. propranolol, atenolol, labetalol)  
• Insulin\textsuperscript{24}  
• Oral hypoglycaemic agents\textsuperscript{6} given for non-diabetes conditions such as polycystic ovarian syndrome (e.g. metformin)  
• Maternal antenatal betamethasone\textsuperscript{25-27} may cause transient fetal adrenal suppression if administered to women after 36 weeks gestation within 24 hours of birth\textsuperscript{28} or multiple courses  
• Terbutaline as tocolysis within previous 48 hours\textsuperscript{6,29} |
| Maternal diabetes       | • Any type of diabetes mellitus—especially if there is poor control and/or a macrosomic baby  
• Maternal diabetes control rather than type or treatment (diet, oral hypoglycaemic medicines or insulin) of diabetes is the important factor\textsuperscript{16,30,31} |
| Known family history    | • Family history of genetic form of hypoglycaemia\textsuperscript{4,6,19} or congenital hyperinsulinaemic disorder or endocrine disorder (e.g. adrenal or pituitary)  
• Sibling or parent of baby with:  
  o MCADD  
  o Other fatty acid oxidation defect, (e.g. long-chain 3-hydroxyacyl-CoA dehydrogenase deficiency (LCHAD)) |
| Intrapartum intravenous (IV) glucose | • IV glucose administration greater than 20 g/hour causing transient hyperinsulinaemia (e.g. Hartmann’s solution with 5% glucose at greater than 400 mL/hour or 10% glucose at greater than 200 mL/hour) |
| Maternal conditions     | • Maternal pre-eclampsia/eclampsia or hypertension or other conditions causing placental insufficiency from any cause\textsuperscript{4,15} |
2.2 Baby risk factors and causes of hypoglycaemia

Some risk factors such as fetal growth restriction (FGR) predispose a baby to hypoglycaemia through several mechanisms.

### Table 3. Risk factors and causes

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Increased glucose utilisation** | • Increased glucose requirements:  
  - Temperature less than 36.5 ºC or labile  
  - Perinatal/birth asphyxia–acidosis (e.g. cord pH less than 7.0, base deficit less than 12 mmol/L, need for prolonged resuscitation)  
  - Infection, congenital heart disease, respiratory disease  
  - FGR—less than 2500 g at term gestation or less than 10th percentile—use clinical judgement considering factors such as the baby’s appearance, and the parental ethnicity and anthropometry and refer to growth charts, (e.g. Appendix A Growth charts)  
  - Polycythaemia/hyperviscosity  
  - Seizures  |
| **Inadequate glucose supply** | • Delayed or inadequate feeding  
  - IV therapy—abrupt cessation or rapid weaning of glucose infusion including infusion infiltration in baby |
| **Inadequate body stores**    | • Inadequate substrate stores or ability to use  
  - FGR—as for increased glucose utilisation above  
  - Gestation—preterm (less than 37+0 weeks gestation) or post-mature (more than 42+0 weeks gestation) or earlier if placental insufficiency  
  - Maternal use of beta-blockers or terbutaline  
  - Severe hepatic dysfunction |
| **Increased levels of insulin** | • Large for gestational age (LGA), FGR—refer to Appendix A Growth charts (example charts)  
  - Hyperinsulinaemia  
  - Persistent neonatal hyperinsulinaemic hypoglycaemia  
  - Leucine sensitivity, isulinoma (rare)  
  - Beckwith-Wiedemann Syndrome; Kabuki syndrome  
  - Perinatal asphyxia or hypoxic stress  
  - Erythroblastosis (e.g. haemolytic disease of the newborn)  
  - Iatrogenic—from erroneous or malicious administration of insulin |
| **Decreased levels of counter-regulatory hormones** | • Impaired glucose homeostasis from endocrine disorders:  
  - Multiple pituitary hormone deficiency including panhypopituitarism  
  - Adrenocorticotropic hormone (ACTH) deficiency  
  - Growth hormone deficiency  
  - Primary adrenal dysfunction (haemorrhage, congenital adrenal hyperplasia)  
  - Other syndromes and endocrine disorders causing pituitary dysfunction:  
    - Suspect if midline defects—facial anomalies, micropenis, midline brain anomalies—detected antenatally (e.g. absent septum pellucidum, absent corpus callosum) |

#### 2.2.1 Other causes

### Table 4. Congenital and other causes

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Congenital anomalies**      | • Beckwith-Wiedemann syndrome/exomphalos, Kabuki syndrome  
  - Other major congenital anomalies or congenital anomaly syndromes  |
| **Disorders of glycolysis**   | • Inborn errors of carbohydrate metabolism—glycogen storage disease types 1 (von Gierke’s), III and IV  |
| **Disorders of gluconeogenesis** | • Inborn errors of carbohydrate metabolism, (e.g. galactosaemia)  
  - Inborn errors of amino acid metabolism, (e.g. maple syrup urine disease; propioncidaemia; methylmalonicacidemia)  
  - Inborn errors of fatty acid oxidation, (e.g. MCADD, LCHAD)  |
| **Unknown or mixed causes**   | • Hypothyroidism  
  • Meconium aspiration syndrome  |
3 Identification

3.1 Screening and assessment of at risk baby (asymptomatic)

- If the baby is symptomatic [refer to Table 6. Clinical signs], they require blood tests and intervention to manage their hypoglycaemia. Refer to Table 8. Initial management
- Target BGL in this section refers to babies in their first 48 hours of life
- Poor sampling techniques (venepuncture or capillary) may provide inaccurate results
- Refer to local protocols and education regarding correct techniques and equipment use

Table 5. Screening

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| Physical assessment\(^{6,30,34}\) | - Identify if baby:  
  o LGA—greater than 90th percentile or greater than 4500 g \(^{19,20}\)  
  o SGA\(^{19,20}\) less than 2500 g at term gestation or less than 10th percentile  
  ▪ Refer to Appendix A Growth charts for example growth charts  
  o Antenatal evidence (ultrasound) of fetal growth restriction, even if greater than 10th percentile  
  - Undertake physical assessment to identify signs associated with neonatal hypoglycaemia  
  - Refer to Table 6. Clinical signs  
  - Refer to Queensland Clinical Guideline Routine newborn assessment\(^{35}\) |
| BGL screening of asymptomatic baby | - 1st BGL before second feed and not later than three hours of age\(^3\)  
  - 2nd BGL screen before third feed and not later than six hours of age  
  - If BGL normal (greater than or equal to 2.6 mmol/L) screen before every second feed—every three to six hours pre-feed for 24 hours depending on feeding frequency  
  - Screen baby with risk factors  
  o Refer to Section 2 Babies at risk |
| BGL screening | - Provide adequate pain relief prior to blood sampling according to local protocols, (e.g. oral sucrose or breastfeeding)  
  - Capillary blood may be used for screening  
  - If available, use point of care gluometer that uses glucose oxidase or glucose dehydrogenase methodology  
  o Otherwise, use a calibrated non-enzymatic gluometer with electrochemical sensor that has been validated for neonatal samples  
  o Non-enzymatic gluometers may be unreliable at lower BGLs |
| Validate BGL less than 2.6 mmol/L | - If screening BGL by gluometer is less than 2.6 mmol/L, or is borderline in a baby with significant risk factors or clinical signs of hypoglycaemia\(^{36}\):  
  o Validate by diagnostic test using point of care analyser (not non-enzymatic gluometer), blood gas analyser or laboratory specimen in fluoride oxalate tube—if feasible and can be accomplished promptly  
  o Do not delay treatment, especially if hypoglycaemia is persistent or recurrent, BGL is less than 2.0 mmol/L or baby is symptomatic  
  - If gluometer BGL is less than or equal to 2.0 mmol/L, confirmation by a validated diagnostic testing method is essential and urgent  
  - If validated BGL less than 2.6 mmol/L, refer to Table 8. Initial management |
3.2 Clinical signs
Hypoglycaemia can be asymptomatic. Measure the BGL and consider the clinical signs in the differential diagnosis. Clinical signs may overlap or be concurrent with other newborn disorders.

Table 6. Clinical signs

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| Neurogenic¹⁸    | • Jitteriness¹² or persistent tremor¹²  
• Breathing–irregular and rapid  
• Sweating  
• Irritability  
• Pallor  |
| Neuroglycopenic¹⁸ | • If neurological signs present, this may represent severe hypoglycaemia⁶  
• Poor feeding  
• Hypotonia¹²  
• Abnormal cry–weak or high-pitched¹²  
• Seizures  
• Changes in level of consciousness–stupor, coma¹²  
• Lethargy¹², apathy  |
| Other           | • Apnoea¹²  
• Bradycardia  
• Cyanosis  
• Tachypnoea¹²  
• Hypothermia¹²  |
4 Management

Any baby with BGL less than 1.5 mmol/L, or who is symptomatic requires urgent management and further investigation. A staged approach to management and further investigation in the first 48 hours of life is indicated in a hypoglycaemic baby with a BGL greater than or equal to 1.5 mmol/L. If there is suspicion or confirmation of hyperinsulinism or other endocrine or metabolic cause for the hypoglycaemia, manage the baby accordingly. Refer to also Section 6 Persistent hypoglycaemia.

4.1 Prevention

Table 7. Prevention

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Recommendation/good practice point</th>
</tr>
</thead>
</table>
| **At birth** | • Keep baby warm–maintain temperature 36.5–37.5 °C per axilla  
• Early skin to skin contact if appropriate and initiation of feeds within 30–60 minutes of birth–discuss feeding cues with mother  
• Feed at least three hourly or more frequently as baby requires  
• Breast feed (preferably) or give expressed breast milk (EBM)  
  o Assist woman with colostrum/breastmilk expression  
• Formula feed if this is maternal choice or with consent if breast milk not available, commence at:  
  o If normal or no risk baby (for hypoglycaemia) 30–40 mL/kg/day  
  o If at risk baby 60–75 mL/kg/day as tolerated  
  o Consider benefits versus disadvantages of giving formula including  
  Disruption to the establishment and duration of breastfeeding |
| **Baby less than 35 weeks gestation or low birth weight** | • Admit to neonatal unit as per local protocols  
  o Contact Retrieval Services Queensland (RSQ) as required  
• Prevent/manage hypothermia  
• If baby’s clinical condition allows, give early and frequent feeds  
  o If baby unable to demonstrate nutritive sucking/feeding, commence gavage feeds  
• Manage other conditions as required |
| **Feeding** | • Breastfeed if baby’s condition allows  
  o Encourage skin-to-skin contact between mother and baby  
• Assist maternal breast milk expression as required  
  o Advise three hourly hand expressing in the first 24 hours until feeding is established  
• If enteral feeding not possible or contraindicated:  
  o Commence IV 10% glucose at 60 mL/kg/day (provides 4.2 mg/kg/minute of glucose)  
  o Refer to Table 14. IV fluids |
| **Complimentary feeding** | • If breastfeeding, complementary feeds of EBM or formula not required in first 24 hours unless:  
  o One BGL less than 2.0 mmol/L OR  
  o Two or more BGL are less than 2.6 mmol/L  
• If complementary feed required, give:  
  o Minimum 7.5 mL/kg/feed (based on 60 mL/kg/24 hours on day one)  
• If breastfeeding effectively and BGL greater than or equal to 2.6 mmol/L, halve complementary feeding quota  
• Then if BGL maintained and baby continues to feed effectively in first 24 hours cease complementary feeds |
| **Symptomatic or unwell baby** | • If baby becomes symptomatic or unwell:  
  o Medical/neonatal nurse practitioner (NNP) review  
  o Admit baby to neonatal unit  
  o Contact RSQ as required  
• Refer to Table 8. Initial management |
4.2 Initial management (first 48 hours of life)

If BGL is less than 2.6 mmol/L, initiate treatment and notify medical officer/NNP immediately or as per local protocols. Increase clinical surveillance and consider other investigations as indicated [refer to Table 16. Medications].

Refer (as required) to: Queensland Clinical Guidelines NeoMedQ Glucagon37 and NeoMedQ Glucose gel 40%38

Table 8. Initial management (first 48 hours of life)

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Recommendation</th>
</tr>
</thead>
</table>
| BGL 1.5–2.5 mmol/L, well and adequate feeding | - If baby greater than or equal to 35+0 weeks gestation, well and feeding  
  o Give glucose gel 40%39 and ensure baby has an effective feed  
  o Feed at least three hourly  
  o Refer to Table 9. Glucose gel |
| BGL 1.5–2.5 mmol/L and inadequate feeding | - Give glucose gel 40% and feed baby  
  o Refer to Table 9. Glucose gel and NeoMedQ Glucose gel 40%38  
  o Notify medical officer/NNP  
  o Consider:  
    o Other observations regarding general condition of baby  
    o Referral to lactation consultant  
    o Other investigations [refer to Table 19. Investigation interpretation]  
  - If BGL less than or equal to 2.0 mmol/L after treatment with glucose gel  
    o Admit to neonatal unit18  
    o Commence IV therapy [refer to Table 14. IV fluids]  
    o Continue breastfeeding (if baby able)  
    - If BGL greater than 2.0 mmol/L and less than 2.6 mmol/L:  
      o Administer glucose gel 40% [refer to Table 9. Glucose gel]  
      o Feed baby immediately–preferably breastfeed  
      ▪ Give oral or enteral colostrum or EBM, or formula, or a combination  
      ▪ Give 60–90 mL/kg/day (6–9 mL/kg)37  
  - If BGL greater than or equal to 2.0 mmol/L and increasing, continue feeding baby and monitoring BGL  
  - If BGL less than 2.0 mmol/L and not increasing, manage as if less than 1.5 mmol/L |
| BGL less than 1.5 mmol/L or unrecordable | - Do not delay treatment–admit to neonatal unit  
  - Validate screening BGL  
    o Refer to Table 5. Screening16,17  
  - Collect diagnostic blood and urine samples  
    o Refer to Table 18. Tests  
  - Establish IV access (peripheral or UVL) (if not already available)  
    o Commence IV therapy and then give IV glucose bolus32  
  - If symptomatic or BGL not improving:  
    o Urgently give glucagon  
    - Repeat BGL by diagnostic test 30 minutes after 10% glucose IV infusion commenced or glucagon administered  
    o Hypoglycaemia non-responsive to glucagon may be due to glycogen storage disease  
    - If not contraindicated, administer glucose gel and continue breastfeeds; or if maternal choice, formula feeds–consider feeds in total fluid volume |
| Difficult IV access | - If IV/UVC access is difficult or delayed more than 15 minutes  
  o Administer stat dose of glucagon by IM or subcutaneous injection  
  - Contact RSQ for advice regarding vascular access option |
| Persistent or suspected long-term hypoglycaemia | - Continue 4–6 hourly BGL and investigate for underlying cause if:  
  o Family history/features of chronic disorder [refer to 2 Babies at risk] OR  
  o BGL not greater than 2.6 mmol/L in first 48 hours OR  
  o Baby is not feeding  
  - Refer to Table 17. Indications for investigations |
4.3 Glucose gel 40%

In Queensland, glucose gel suitable for the management of neonatal hypoglycaemia is supplied off label for newborn use as 15 grams of glucose per 37.5 gram tube (Glucose 15®). This is equivalent to 40% glucose. The label states it is an oral preparation but is administered buccally in the newborn baby. Although the label states not to use this preparation in children less than two years of age, it is considered safe and effective for treatment of transient hypoglycaemia in the newborn. It is recommended, to avoid confusion when it is required urgently, that pharmacy departments label ward stock of the gel accordingly and include the dose of 0.5 mL/kg on the label. Also, refer to NeoMedQ https://www.health.qld.gov.au/qcg/neonatal-medicines.

Table 9. Glucose gel

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration/recommendation</th>
</tr>
</thead>
</table>
| Context      | • Effective adjunct to oral feeding in the first 48 hours of life during periods of transient hypoglycaemia  
• A single buccal dose (200 mg/kg) 0.5 mL/kg of glucose 40% gel reduces incidence of hypoglycaemia (RR 0.68; 95% CI 0.47 to 0.99, p=0.04)  
• Reduces incidence of hypoglycaemia compared with placebo (RR 0.79; 95% CI 0.64 to 0.98, p=0.03; NNT=10, 95% CI 5 to 115)  
• Reduces admission to Neonatal Intensive Care Unit for hypoglycaemia (RR 0.46; 95% CI 0.21 to 1.01, p=0.05)  
• Treatment with glucose gel does not affect neurosensory outcome at two years of age |
| Criteria to escalate | • Notify medical officer or NNP after glucose gel administered if:  
  o BGL remains less than 2.6 mmol/L  
  o Baby becomes unwell or is feeding poorly  
• Admit to neonatal unit if:  
  o BGL less than 2.6 mmol/L despite two doses of glucose gel 40% and breastfeed or EBM or formula feed (combined volume of 60 mL/kg/day)  
  o BGL less than 1.5 mmol/L at any time |
| Repeat doses | • Up to 6 doses within the first 48 hours of life may be considered if:  
  o Baby’s clinical examination by medical officer or NNP is normal AND  
  o Baby is asymptomatic AND  
  o Baby is feeding well AND  
  o Prefeed BGL is greater than 2.0 mmol/L AND  
  o BGL is rising after each glucose gel dose  
• If baby has risk factors and requires a third consecutive dose admit to neonatal unit and consider discussing with a neonatologist |
| Administration | • To administer:  
  o Dry baby’s buccal mucosa with gauze  
  o Rub into buccal mucosa  
• Breastfeed baby immediately after administration |
| Feeding      | • Immediate breast feeding after glucose gel administration improves the quality of subsequent breast feeds  
• Breast feeding reduces requirement for repeated glucose gel doses (OR 0.52; 95% CI 0.28 to 0.94)  
• EBM has less effect as an adjunct with glucose gel to maintain the baby’s BGL  
• Continue to encourage exclusive breastfeeding if possible, although formula may be required if the BGL is persistently low |

*Refer to an Australian pharmacopoeia for complete drug information
4.3.1 **Glucose gel doses**
For dosing based on baby’s weight refer to Appendix B Glucose 40% gel doses

Table 10. Glucose gel regimen

<table>
<thead>
<tr>
<th>BGL level</th>
<th>Glucose gel dose</th>
<th>Good practice point</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Less than 1.5 mmol/L at any time</strong></td>
<td>Nil or any doses</td>
<td>• If possible, give glucose gel 40% and feed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Admit baby to neonatal unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Commence IV glucose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Refer to Table 14. IV fluids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Consider other management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Refer to Table 11. BGL measurement</td>
</tr>
<tr>
<td><strong>1.5–2.5 mmol/L</strong></td>
<td>Administer dose</td>
<td>• Give 0.5 mL/kg of glucose gel 40% (200 mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Breast feed baby or give 60 mL/kg of formula, EBM or a combination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Repeat BGL 30 minutes after dose</td>
</tr>
<tr>
<td><strong>2.0–2.5 mmol/L</strong></td>
<td>After first dose</td>
<td>• Repeat glucose gel 40% dose (200 mg/kg) followed by a feed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Assess and check baby’s feeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Repeat BGL 30 minutes after dose</td>
</tr>
<tr>
<td><strong>2.0–2.5 mmol/L</strong></td>
<td>After second dose</td>
<td>• Repeat glucose gel 40% dose (200 mg/kg) up to 6 doses in 48 hours—no more than 2 doses in succession, each time followed by a feed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o If two doses given and/or six doses in 48 hours manage as for baby with BGL less than or equal to 1.5 mmol/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Assess and check baby’s feeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Repeat BGL 30 minutes after dose</td>
</tr>
<tr>
<td><strong>Less than 2.0 mmol/L</strong></td>
<td>After second dose</td>
<td>• Admit baby to neonatal unit for IV glucose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Refer to Table 14. IV fluids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Feed baby as indicated and able</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Maintain baby’s temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Assess for any other signs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Consider the nature of the baby’s risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Consider other management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Refer to Table 11. BGL measurement</td>
</tr>
</tbody>
</table>
4.4 Ongoing management
If glucose infusion rate (GIR) greater than 8 mg/kg/minute, consider administering glucagon infusion to minimise interference with the establishment of breast feeding, avoid fluid overload and lessen pancreatic over stimulation with high glucose delivery. Consult with a neonatologist for advice regarding management and investigations by contacting RSQ.

4.4.1 BGL measurement

Table 11. BGL measurement

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL frequency</td>
<td>• Hourly until greater than or equal to 2.6 mmol/L, then 4–6 hourly prefeed</td>
</tr>
<tr>
<td></td>
<td>• 30 minutes after any change to concentration or volume of IV glucose</td>
</tr>
<tr>
<td>Optimal BGL&lt;sup&gt;4&lt;/sup&gt;</td>
<td>• Greater than or equal to 2.6 mmol/L in first 24 hours</td>
</tr>
<tr>
<td></td>
<td>• Greater than or equal to 3.3 mmol/L after 48 hours or as advised by</td>
</tr>
<tr>
<td></td>
<td>neonatologist or paediatric endocrinologist&lt;sup&gt;42&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Greater than or equal to 4 mmol/L for suspected or known persistent</td>
</tr>
<tr>
<td></td>
<td>hypoglycaemic disorder (e.g. endocrine or metabolic disorder) at any time</td>
</tr>
<tr>
<td>Neonatologist/paediatric consult</td>
<td>• If at any time the BGL is:</td>
</tr>
<tr>
<td>indicated</td>
<td>o Less than 2.6 mmol/L on three occasions or</td>
</tr>
<tr>
<td></td>
<td>o Less than 1.6 mmol/L on two occasions</td>
</tr>
<tr>
<td></td>
<td>• Refer to Table 20. Ongoing long term management</td>
</tr>
<tr>
<td>Weaning IV glucose</td>
<td>• If BGL greater than or equal to 3.0 mmol/L for 12 hours on first day of life</td>
</tr>
<tr>
<td></td>
<td>or greater than or equal to 4 mmol/L on second day of life:</td>
</tr>
<tr>
<td></td>
<td>o Gradually reduce IV glucose as enteral feeds increase</td>
</tr>
<tr>
<td></td>
<td>o If GIR is greater than or equal to 8 mg/kg/minute, reduce the infusion by</td>
</tr>
<tr>
<td></td>
<td>2 mg/kg/minute every six hours</td>
</tr>
<tr>
<td></td>
<td>o If GIR is less than 8 mg/kg/minute weaning may be quicker</td>
</tr>
<tr>
<td>Monitoring during weaning of IV</td>
<td>• Before and during weaning, continue to monitor BGL and consider:</td>
</tr>
<tr>
<td>glucose</td>
<td>o Glucose concentration and volume of fluid being infused (mL/kg/day)</td>
</tr>
<tr>
<td></td>
<td>o How well the baby’s feeding is being established</td>
</tr>
<tr>
<td></td>
<td>o Medications the baby is receiving to treat hypoglycaemia</td>
</tr>
<tr>
<td></td>
<td>▪ If IV glucagon infusion is used, wean when full feeds achieved</td>
</tr>
<tr>
<td></td>
<td>o If hydrocortisone used, wean when on full feeds and glucagon ceased</td>
</tr>
</tbody>
</table>

4.4.2 Ceasing BGL monitoring

Table 12. Ceasing BGL

<table>
<thead>
<tr>
<th>Lowest BGL</th>
<th>Criteria for ceasing BGL monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.6 mmol/L or more</td>
<td>Not hypoglycaemic</td>
</tr>
<tr>
<td>(well at risk baby)</td>
<td>• Baby is well and feeding effectively</td>
</tr>
<tr>
<td>BGL 1.5–2.5 mmol/L</td>
<td>• BGL greater than or equal to:</td>
</tr>
<tr>
<td>within first 48 hours</td>
<td>o 2.6 mmol/L for 24 hours in first 48 hours or</td>
</tr>
<tr>
<td>BGL less than 1.5</td>
<td>• Baby REQUIRED IV glucose</td>
</tr>
<tr>
<td>mmol/L or symptomatic</td>
<td>▪ IV glucose has been ceased for 12 hours or more</td>
</tr>
<tr>
<td>or known disorder</td>
<td>• Baby is well and feeding effectively</td>
</tr>
<tr>
<td></td>
<td>• BGL is greater than or equal to:</td>
</tr>
<tr>
<td></td>
<td>o 2.6 mmol/L prior to 3 consecutive enteral feeds within first 48 hours or</td>
</tr>
<tr>
<td></td>
<td>o 3.3 mmol/L after 48 hours</td>
</tr>
<tr>
<td></td>
<td>▪ Baby has known hypoglycaemic disorder, BGL is greater than or equal to:</td>
</tr>
<tr>
<td></td>
<td>o 2.6 mmol/L (after 6 hour fast test)</td>
</tr>
</tbody>
</table>
### 4.4.3 Other management

#### Table 13. Ongoing management

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid management</td>
<td>• If required, increase volume of fluid administered</td>
</tr>
<tr>
<td></td>
<td>o An increase of 20 mL/kg/day (from 60 mL/kg/day to 80 mL/kg/day) provides a 33% increase in glucose</td>
</tr>
<tr>
<td></td>
<td>o Check sodium level—if low prepare a solution with increased glucose concentration for equivalent glucose delivery rate, or commence or increase glucagon infusion and reduce fluid intake</td>
</tr>
<tr>
<td></td>
<td>• Increase the concentration of glucose to 12% or step-wise to higher concentration as required</td>
</tr>
<tr>
<td></td>
<td>o Refer to Appendix C Glucose infusion rates (GIR)</td>
</tr>
<tr>
<td></td>
<td>• Glucose 12% provides a 20% increase in glucose</td>
</tr>
<tr>
<td></td>
<td>o If the required IV infusion concentration is greater than 12% insert umbilical venous catheter (UVC) or central line</td>
</tr>
<tr>
<td></td>
<td>• If required, increase volume to 100 mL/kg/day maximum in first 24 hours42</td>
</tr>
<tr>
<td></td>
<td>o Consider risk of fluid overload</td>
</tr>
<tr>
<td></td>
<td>o Review serum sodium and other electrolyte levels regularly</td>
</tr>
<tr>
<td></td>
<td>• If not contraindicated, continue feeds and include these in the fluid calculation</td>
</tr>
<tr>
<td>Further investigations and management</td>
<td>• Consider further investigations and pharmacological intervention⁶ if:</td>
</tr>
<tr>
<td></td>
<td>o IV glucose rate greater than or equal to 8 mg/kg/minute, OR</td>
</tr>
<tr>
<td></td>
<td>o Baby is more than 48 hours of age, OR</td>
</tr>
<tr>
<td></td>
<td>o Baby presents with hypoglycaemia for the first time after 24 hours, OR</td>
</tr>
<tr>
<td></td>
<td>o BGL is difficult to control</td>
</tr>
<tr>
<td></td>
<td>o Refer to Table 16. Medications Refer to Table 17. Indications for investigations</td>
</tr>
</tbody>
</table>

#### 4.5 Intravenous glucose

Consider administering glucose gel 40% buccally while admitting baby to neonatal unit and inserting intravenous cannula. Refer to Table 9. Glucose gel.

#### Table 14. IV fluids

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Recommendation/good practice point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indications</td>
<td>• Baby with risk factors for hypoglycaemia who is not feeding</td>
</tr>
<tr>
<td></td>
<td>o Refer to Section 2. Babies at risk</td>
</tr>
<tr>
<td></td>
<td>o Breastfeeding baby when formula is indicated but consent is withheld</td>
</tr>
<tr>
<td></td>
<td>• BGL less than 1.5 mmol/L or unrecordable and/or any signs consistent with severe hypoglycaemia</td>
</tr>
<tr>
<td>Escalation points</td>
<td>• If greater than 12% glucose required administer via central catheter—umbilical vein catheter or peripherally inserted central catheter (PICC)</td>
</tr>
<tr>
<td></td>
<td>• If IV access delayed, administer glucagon³ by intramuscular or subcutaneous injection [refer to Table 16. Medications]</td>
</tr>
<tr>
<td></td>
<td>• Discuss baby’s management with neonotologist via RSQ if:</td>
</tr>
<tr>
<td></td>
<td>o Frequent or prolonged hypoglycaemia [refer to Table 20. Ongoing long term management]</td>
</tr>
<tr>
<td></td>
<td>o Glucose infusion concentration is greater than 14% or GIR is greater than 8 mg/kg/minute</td>
</tr>
<tr>
<td></td>
<td>o Glucagon or hydrocortisone or other medication is required</td>
</tr>
<tr>
<td>Bolus dose</td>
<td>• Not required for baby who only has risk factors or has mild, transient hypoglycaemia (BGL greater than 1.5 mmol/L in first 48 hours of life) and is feeding</td>
</tr>
<tr>
<td></td>
<td>• Use bolus doses of glucose sparingly except where severe or symptomatic hypoglycaemia</td>
</tr>
<tr>
<td></td>
<td>• Urgently—slowly administer 10% glucose 1–2 mL/kg (100–200 mg/kg) IV as bolus dose¹⁶ increase IV glucose infusion rate</td>
</tr>
<tr>
<td></td>
<td>o Use clinical judgement regarding the severity of the hypoglycaemia and consider risk of rebound hypoglycaemia</td>
</tr>
<tr>
<td></td>
<td>• Repeat BGL after 30 minutes and if indicated repeat dose at 1 mL/kg</td>
</tr>
</tbody>
</table>
### 4.5.1 Regimen for glucose infusion

**Table 15. Regimen for glucose infusion**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Recommendation/good practice point</th>
</tr>
</thead>
</table>
| **Commencement** | • Commence 10% glucose IV infusion at 60 mL/kg\(^{43}\) to give 4.2 mg/kg/minute of glucose  
• Calculate IV glucose in mg/minute  
  o Refer to Appendix C Glucose infusion rates (GIR)  
• Baby with hyperinsulinaemia may require higher glucose concentration\(^3\)  
• Baby requiring high glucose concentration may have hyperinsulinism  
• Baby with endocrine deficiency or inborn error of metabolism more likely to require only 4–6 mg/kg/minute of glucose to maintain euglycaemia |
| **Severe or persistent hypoglycaemia** | • As required:  
  o If severe or persistent hypoglycaemia increase the fluid volume before the concentration as this will result in an immediate change in glucose delivery rate  
  o Increase IV glucose in 20 mL/kg/day increments (e.g. 60 mL/kg/day to 80 mL/kg/day)–a temporary increase in volume may be required while solution of increased glucose concentration is prepared  
  o Administer glucagon [refer to Table 16. Medications]  
• Increase IV glucose concentration to 12 % or step-wise to a higher concentration\(^24\)  
  o Refer to Appendix D Preparing glucose concentrations for infusion  
• If baby is less than 24 hours of age, 100 mL/kg/day total fluid intake is maximum most babies are likely to tolerate without developing fluid overload (some babies may develop hyponatraemia at lower infusion rates)  
  o Consider higher glucose concentration and commencing glucagon infusion |
| **Hyponatraemia risk** | • If hyponatraemic or fluids greater than or equal to 100 mL/kg/day (especially in first 24 hours of life):  
  o Consider risk of fluid overload [refer to Table 11. BGL measurement]  
  o Insert central access line (as soon as possible when time allows), for administration of increased concentration and reduced fluid volume  
  o Consider commencing glucagon infusion and/or  
  o Administer hydrocortisone–may be preferred option if laboratory or clinical evidence suggesting hypoadrenalism or if insufficient response to glucagon, or baby is also hypotensive  
  o If not contraindicated, continue enteral feeds  
• Review serum sodium levels regularly |
| **Weaning** | • General principles of weaning treatment:  
  o Wean IV glucose and increase to full feeds (appropriate for day of age), then  
  o Wean glucagon (if used), then  
  o Wean hydrocortisone (if used)  
  ▪ If hyperinsulinaemia is the cause of hypoglycaemia, consider weaning hydrocortisone earlier to avoid adrenal suppression–discuss with paediatric endocrinologist  
• If difficult weaning, consult with neonatologist via RSQ for further discussion with paediatric endocrinologist or metabolic specialist as indicated |
5 Medications

If BGL does not normalise after buccal glucose gel 40% [refer to Table 9. Glucose gel] or IV glucose consider other medication(s) to manage hypoglycaemia. Take blood samples immediately before commencing medications while the baby is hypoglycaemic. Consider discussion with a neonatologist paediatric endocrinologist or paediatric metabolic physician by contacting RSQ.


Table 16. Medications

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| Glucagon37    | • Indicated for babies with refractory hypoglycaemia when liver glycogen stores are available (as increases gluconeogenesis and glycogenolysis)\(^16\)   
  • Effective for babies of women with diabetes or other hyperinsulinaemic conditions proven to be refractory to intravenous glucose infusion  
  • May be less likely to be effective in FGR babies (due to lower glycogen stores)–although many do respond  
  • If IV access delayed or difficult may be given by IM or subcutaneous injection  
  • Blood glucose level should rise within one hour of commencing infusion and lasts approximately two hours\(^47\)–commence concomitant intravenous glucose infusion to avoid rebound hypoglycaemia |
| Hydrocortisone46 | • Reduces peripheral glucose utilisation and increases gluconeogenesis  
  • Has a slower response than glucagon |
| Diazoxide45   | • Potassium channel activator that inhibits insulin release from the pancreas  
  • If persistent hypoglycaemia, use to wean from glucose infusion and for long-term management |
| Hydrochlorothiazide40 | • Diuretic given in conjunction with diazoxide  
  • Inhibits pancreatic release of insulin |
| Octreotide44  | • Hyperinsulinaemic hypoglycaemia is known or suspected  
  o Not usually commenced in the newborn period–consult with paediatric endocrinologist |
6 Persistent hypoglycaemia
Hypoglycaemia persisting beyond 48 hours requires further investigation and management.

6.1 Further investigation and management

Table 17. Indications for investigations

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context</td>
<td>• Investigation and management are required for severe, persistent, recurrent or atypical hypoglycaemia&lt;sup&gt;3,15,31&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Investigate the underlying mechanism for the hypoglycaemia to identify specific treatment requirements&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>o Refer to Table 18. Tests</td>
</tr>
<tr>
<td></td>
<td>• If further investigations are required early discussion with a neonatologist is indicated to advise:</td>
</tr>
<tr>
<td></td>
<td>o Regarding paediatric endocrinology consultation</td>
</tr>
<tr>
<td></td>
<td>o Need for retrieval to a tertiary neonatal unit</td>
</tr>
<tr>
<td>Presentation</td>
<td>• Symptomatic hypoglycaemia&lt;sup&gt;15,30&lt;/sup&gt; or need for glucose IV to treat after 48 hours of age&lt;sup&gt;6,15&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Seizures or altered level of consciousness</td>
</tr>
<tr>
<td></td>
<td>• Inability to consistently maintain pre-prandial BGL:</td>
</tr>
<tr>
<td></td>
<td>o Greater than or equal to 2.6 mmol/L up to 48 hours of age or 3.3 mmol/L beyond first 48 hours OR</td>
</tr>
<tr>
<td></td>
<td>o If known hypoglycaemia condition, and less than 4 mmol/L after 48 hours&lt;sup&gt;48&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Unusual presentation of hypoglycaemia or baby with no known risk factors</td>
</tr>
<tr>
<td>Severe</td>
<td>• If not a baby of a woman with diabetes, low BGL (less than 1.5 mmol/L in first 6 hours of life) preterm or birth weight less than 1500 g</td>
</tr>
<tr>
<td>hypoglycaemia</td>
<td>• Persistent or recurrent hypoglycaemia despite glucose IV greater than or equal to 8 mg/kg/minute&lt;sup&gt;69&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Required treatment with medication</td>
</tr>
<tr>
<td>Late hypoglycaemia</td>
<td>• BGL less than 2.6 mmol/L onset after 24 hours of life</td>
</tr>
<tr>
<td></td>
<td>• Early onset persistent or any hypoglycaemia recurrent after 48 hours</td>
</tr>
<tr>
<td>Family history</td>
<td>• Genetic hypoglycaemia</td>
</tr>
<tr>
<td></td>
<td>• Inborn errors of metabolism in parent or sibling,(e.g. MCADD&lt;sup&gt;18&lt;/sup&gt;, LCHAD or other fatty acid oxidation defect)</td>
</tr>
<tr>
<td></td>
<td>• Endocrine disorders</td>
</tr>
<tr>
<td></td>
<td>• Sudden infant death syndrome&lt;sup&gt;30&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Reye's syndrome&lt;sup&gt;30&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Developmental delay&lt;sup&gt;30&lt;/sup&gt;</td>
</tr>
<tr>
<td>Abnormalities</td>
<td>• Presence of associated abnormalities (e.g. midline facial malformations, microcephalus; exomphalos)&lt;sup&gt;30&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
### 6.2 Pathology tests

Table 18. Tests

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Blood**<sup>3,4,49</sup> | - Take venous or arterial samples only  
- Identify *Neonatal Hypoglycaemia* on the request form and ask for urgent testing by pathology service  
- Advise limited volume of blood available for testing  
- Don’t allow blood specimen to haemolyse as this may lead to an artificially low insulin level<sup>50</sup>  
- Take blood specimens immediately *before* treatment while baby is hypoglycaemic |
| **Priority** | **Specimen** |
| 1 | - Blood gas syringe or capillary tube–blood gas, lactate, glucose, electrolytes, haemoglobin, haematocrit  
- Serum (red pedi-pot) 0.5 mL for cortisol and insulin  
- Lithium heparin (green pedi-pot) 0.5 mL for acylcarnitine profile or separate/additional neonatal screening card |
| 2 | - Serum (red pedi-pot) 0.5 mL for growth hormone |
| 3 | - Lithium heparin (green pedi-pot) 0.5 mL for plasma amino acids  
- EDTA* (purple pedi-pot) 0.5 mL for ammonium–notify and send to laboratory urgently  
- Serum (red pedi-pot) 1 mL for electrolytes and liver function tests (LFTs) OR 0.5 mL for LFTs only  
- Pyruvate (tube from laboratory) 0.5 mL for pyruvate  
- Serum (red pedi-pot) 0.4 mL for beta hydroxybutyrate |
| **Urine** | - Metabolic screen  
  o First sample *after* hypoglycaemic episode  
  o Do not wait to start treatment while collecting sample  
- Collect 10 mL if possible (send available volume from one sample only) |

*EDTA–Ethylenediaminetetraacetic acid*
6.3 Interpretation of investigations

Conditions causing hypoglycaemia may occur concurrently, (e.g. hyperinsulinaemia with low cortisol due to prematurity or hyperinsulinaemia and low cortisol and low growth hormone due to pituitary disorder).

Table 19. Investigation interpretation

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyper-insulinaemic state⁴</td>
<td>• Occurs when there is detectable insulin when baby is hypoglycaemic</td>
</tr>
<tr>
<td></td>
<td>• Confirmed by low levels or absence of free fatty acids (less than 1 mmol/L)</td>
</tr>
<tr>
<td></td>
<td>• Beta hydroxy-butryrate (less than 1.8 mmol/L)</td>
</tr>
<tr>
<td></td>
<td>• Usually transient but may be persistent and require long-term treatment</td>
</tr>
<tr>
<td></td>
<td>• In absence of maternal diabetes, consult with neonatologist via RSQ for</td>
</tr>
<tr>
<td></td>
<td>paediatric endocrinologist advice</td>
</tr>
<tr>
<td>Cortisol⁴,3⁰,5¹</td>
<td>• If more than 200 nmol/L—likely to be a normal response</td>
</tr>
<tr>
<td></td>
<td>o May be blunted in preterm baby, hyperinsulinism or prolonged hypoglycaemia</td>
</tr>
<tr>
<td></td>
<td>of any cause</td>
</tr>
<tr>
<td></td>
<td>• If lesser response—suggestive of hypothalamic, pituitary or adrenal dysfunction</td>
</tr>
<tr>
<td></td>
<td>o Consult urgently with neonatologist via RSQ for paediatric endocrinologist advice</td>
</tr>
<tr>
<td>Growth hormone³⁰</td>
<td>• Test has good sensitivity but relatively poor specificity</td>
</tr>
<tr>
<td></td>
<td>• Greater than or equal to 7 micrograms per litre (20 mIU/L)—normal response during hypoglycaemia in term baby (may be blunted in preterm baby)</td>
</tr>
<tr>
<td></td>
<td>• If lesser response—may be suggestive of hypothalamic or pituitary dysfunction</td>
</tr>
<tr>
<td></td>
<td>o Consult urgently with neonatologist via RSQ for paediatric endocrinologist advice</td>
</tr>
<tr>
<td>Ammonia</td>
<td>• If greater than 100 micromol/L consider metabolic disorder (e.g. urea cycle defect)⁵² or hyperinsulinaemia hyperammonaemia syndrome</td>
</tr>
<tr>
<td></td>
<td>o Consult urgently with neonatologist via RSQ for paediatric metabolic specialist advice</td>
</tr>
<tr>
<td>Severe/persistent/ recurrent</td>
<td>• Refer to Table 20. Ongoing long term management</td>
</tr>
<tr>
<td>hypoglycaemia</td>
<td>• If endocrine disorder not identified—consult urgently with neonatologist via</td>
</tr>
<tr>
<td></td>
<td>RSQ for paediatric endocrinologist and/or metabolic specialist advice</td>
</tr>
</tbody>
</table>

6.4 Long term management

Table 20. Ongoing long term management

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultation</td>
<td>• Consult with neonatologist via RSQ for advice from paediatric endocrinologist, metabolic specialist or both¹⁸</td>
</tr>
<tr>
<td></td>
<td>• If hypoglycaemia:</td>
</tr>
<tr>
<td></td>
<td>o Severe (less than 1.5 mmol/L), recurrent (more than three sequential</td>
</tr>
<tr>
<td></td>
<td>episodes of BGL less than 2.6 mmol/L) or prolonged or lasts longer</td>
</tr>
<tr>
<td></td>
<td>than 48 hours</td>
</tr>
<tr>
<td>Severe or persistent hypoglycaemia</td>
<td>• Endocrine or metabolic conditions that predispose to persistent hypoglycaemia may first present as transient neonatal hypoglycaemia, (e.g. hypopituitism) and settle</td>
</tr>
<tr>
<td></td>
<td>• Persistent hypoglycaemic conditions may result in neurological damage if:</td>
</tr>
<tr>
<td></td>
<td>o Mild but recurrent hypoglycaemia or</td>
</tr>
<tr>
<td></td>
<td>o Feeds are delayed or interrupted (e.g. due to recurrent illness)</td>
</tr>
<tr>
<td></td>
<td>• Exclude persistent or prolonged hypoglycaemic conditions</td>
</tr>
<tr>
<td></td>
<td>o Persistent hyperinsulinaemic conditions⁵⁴—if low level of ketones</td>
</tr>
<tr>
<td></td>
<td>present the risk is increased</td>
</tr>
<tr>
<td></td>
<td>o Endocrine deficiencies, for example hypopituitarism and hypoadrenalism</td>
</tr>
<tr>
<td></td>
<td>o Inborn errors of metabolism (e.g. fatty acid oxidation defects)</td>
</tr>
<tr>
<td>Fasting test</td>
<td>• Prior to discharge [refer to Table 21. Six hour fast test]</td>
</tr>
</tbody>
</table>
### 6.5 Six hour fast test

Prior to commencing the six hour fast test consult with a neonatologist via RSQ for advice (may include input from a paediatric endocrinologist or metabolic specialist).

Table 21. Six hour fast test

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Context** | • Six hours duration unless otherwise recommended by endocrinologist or metabolic specialist  
• Identifies baby requiring additional investigation or management

• If baby has known prolonged or persistent hypoglycaemic disorder (e.g. hyperinsulinaemia, or has had clinically significant hypoglycaemia test ensures baby can maintain normoglycaemia (in a fasted state after discharge)

• Test is conducted on discharge medications (e.g. diazoxide and hydrochlorothiazide) if these have been recommended |
| **Indications** | • Family history of hypoglycaemia or congenital anomalies suggestive of pituitary or adrenal disorder to screen for persistent hypoglycaemic disorder despite normal previous BGLs

• History of clinically significant hypoglycaemia to identify a baby who requires testing for a persistent disorder

  - Baby required IV glucose greater than 6 mg/kg/minute or medication to maintain normoglycaemia |
| **BGL** | • Check at four, five and six hours post feed (omit further feeds during test)

• If known family history or congenital anomaly--BGL target is greater than or equal to 4 mmol/L

• If history of clinically significant hypoglycaemia--BGL target is above 3.3 mmol/L |
| **Actions** | • If BGL less than 3 mmol/L at any time

  - Perform investigations as to the cause and then feed baby

  - Continue BGL monitoring

  - Delay discharge of baby

  - Consult with neonatologist via RSQ for advice from paediatric endocrinologist or metabolic specialist

• If baby symptomatic between scheduled BGL measures

  - Check BGL early

    - If low--perform investigations and then feed baby

• If baby asymptomatic and BGL greater than or equal to 3 mmol/L throughout--finish test and feed baby

• If BGL less than 4 mmol/L, baby requires further assessment and management before discharge

  - Consult with paediatric endocrinologist

  - Continue prefeed BGL monitoring |
7  Sequelea of hypoglycaemia

Table 22. Sequelae

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| Context                             | • Both **symptomatic** and **asymptomatic** hypoglycaemia leads to adverse neurodevelopment outcome when compared with euglycaemic babies\(^53\)
• Magnetic resonance imaging occasionally useful to assist with prognosis or rule out other pathology
  o At discretion of neonatologist, or paediatric endocrinologist or metabolic specialist
| Neurodevelopmental outcome          | • Cognitive impairment more likely than motor impairment\(^54\)
• May present in neonatal period as encephalopathy with\(^55\):
  o Poor feeding
  o Lethargy
  o Seizures
  o Hypothermia
  o Respiratory distress
• Hypoglycaemic encephalopathy:
  o Usually injury to posterior region of brain typically the occipital cortex\(^55\) or parietal lobes\(^54\)
  o Develops in white matter\(^54\)
  o May follow neonatal focal or generalised seizures resulting from symptomatic hypoglycaemia\(^21\)
• Potential short and long-term sequelae include:
  o Head growth suboptimal consistent with white matter injury\(^54\) intellectual disability, learning difficulties, behavioural difficulties\(^21\), visual co-ordination, visual impairment\(^21\)
  o Hemiplegic cerebral palsy or spastic quadriplegia; milder motor problems\(^21\)

8  Discharge planning

Table 23. Discharge planning

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| Discharge planning                  | • Consider six hour fast with BGL monitoring to exclude:
  o Persistent hyperinsulaenic conditions
  o Endocrine deficiencies
  o Inborn errors of metabolism\(^5\),\(^6\)
  o Hypoglycaemia despite medication (e.g. diazoxide and hydrochlorothiazide) prescribed for discharge
  o Refer to Table 21. Six hour fast test
• If in doubt, discuss with neonatologist, paediatric endocrinologist or metabolic specialist
| Discharge criteria                   | • Baby less than 48 hours of age and pre-prandial BGL is greater than 2.6 mmol/L for three feed-fast cycles [refer to Table 11. BGL measurement]
• If known hypoglycaemic condition and baby more than or equal to 48 hours of age and pre-prandial BGL is greater than 4 mmol/L for three feed-fast cycles\(^7\)
• Six hour fast test performed (if indicated) and baby able to maintain BGL
| Parent education                    | • Discuss causes, risks, potential sequelae and management
• Include signs that require escalation and the escalation plan
• Provide parent information brochure
| Follow-up                           | • Usual follow-up with general practitioner and child health nurse
• If symptomatic, severe, recurrent or atypical hypoglycaemia including:
  o Follow up by paediatrician or neonatologist
  o Endocrinologist or metabolic specialist follow-up as indicated
• Arrange other follow up as per local protocols
| Reducing risk in subsequent pregnancies | • Maternal lifestyle—healthy weight and diet management
• Genetic counselling/family history
• Glycaemic/diabetes management
• Refer to Queensland Clinical Guideline *Gestational diabetes*\(^56\)
References


Appendix A Growth charts examples

Growth chart for girls

Curves equal the WHO Growth Standard at 50 weeks.

Sources: Infant to age 2—Australia (Aldred 2010), United States (Cohen 2010), Canada (Kramer 2001), Scotland (Benetti 2009), and Italy (Berkovitz 2013). Preterm section—the World Health Organization Growth Standard, 2006.
Growth chart for boys

![Growth chart for boys](image)

Curves equal the WHO Growth Standard at 50 weeks.
Sources: Intrauterine section - Germany (Wright 2010), United States (Center 2010), Australia (Ridolfo 1998), Canada (Korner 2001), Scotland (Bonnell 2008), and Italy (Berton 2015). Post-term section - the World Health Organization Growth Standard, 2006.

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Appendix B Glucose 40% gel doses

<table>
<thead>
<tr>
<th>Baby's weight</th>
<th>Dose of glucose 40% gel 0.5 mL/kg (200 mg/kg) for buccal administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000–2080 g</td>
<td>1 mL</td>
</tr>
<tr>
<td>2081–2280 g</td>
<td>1.1 mL</td>
</tr>
<tr>
<td>2281–2480 g</td>
<td>1.2 mL</td>
</tr>
<tr>
<td>2481–2680 g</td>
<td>1.3 mL</td>
</tr>
<tr>
<td>2681–2880 g</td>
<td>1.4 mL</td>
</tr>
<tr>
<td>2881–3080 g</td>
<td>1.5 mL</td>
</tr>
<tr>
<td>3081–3280 g</td>
<td>1.6 mL</td>
</tr>
<tr>
<td>3281–3480 g</td>
<td>1.7 mL</td>
</tr>
<tr>
<td>3481–3680 g</td>
<td>1.8 mL</td>
</tr>
<tr>
<td>3681–3880 g</td>
<td>1.9 mL</td>
</tr>
<tr>
<td>3881–4080 g</td>
<td>2.0 mL</td>
</tr>
<tr>
<td>4081–4280 g</td>
<td>2.1 mL</td>
</tr>
<tr>
<td>4281–4480 g</td>
<td>2.2 mL</td>
</tr>
<tr>
<td>4481–4680 g</td>
<td>2.3 mL</td>
</tr>
<tr>
<td>4681–4880 g</td>
<td>2.4 mL</td>
</tr>
<tr>
<td>4881–5080 g</td>
<td>2.5 mL</td>
</tr>
</tbody>
</table>
Appendix C Glucose infusion rates (GIR)

How to calculate GIR (mg/kg/minute) when mL/hour are known (method 1)*

\[
\text{GIR (mg/kg/minute)} = \frac{\text{glucose being infused} \times \text{rate of infusion (mL/hour)}}{\text{Weight} \times 6}
\]

Example—GIR for 4.5 kg baby having 18.75 mL/hour of 12% glucose

\[
\text{GIR (mg/kg/minute)} = \frac{12\% \times 18.75 \text{ mL/hour}}{4.5\text{ kg} \times 6} = 8.34 \text{ mg/kg/minute}
\]

OR

How to calculate GIR (mg/kg/minute) when mL/hour are known (method 2)*

\[
\text{GIR (mg/kg/minute)} = \frac{\text{glucose being infused} \times \text{rate of infusion (mL/kg/day)}}{144}
\]

Example—GIR for 4.5 kg baby having 100 mL/kg/day of 12% glucose

\[
\text{GIR (mg/kg/minute)} = \frac{12\% \times 100 \text{ mL/kg/day}}{144} = 8.34 \text{ mg/kg/minute}
\]

GIR quick reference for commonly used concentrations*

<table>
<thead>
<tr>
<th>Glucose mg/kg/minute</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose %</td>
<td>mL/kg/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4.2</td>
<td>5.6</td>
<td>6.9</td>
<td>8.3</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>6.7</td>
<td>8.3</td>
<td>10</td>
</tr>
<tr>
<td>12.5</td>
<td>5.2</td>
<td>6.95</td>
<td>8.68</td>
<td>10.4</td>
</tr>
<tr>
<td>14</td>
<td>5.8</td>
<td>7.8</td>
<td>9.7</td>
<td>11.7</td>
</tr>
<tr>
<td>15</td>
<td>6.25</td>
<td>8.3</td>
<td>10.42</td>
<td>12.5</td>
</tr>
<tr>
<td>16</td>
<td>6.7</td>
<td>8.9</td>
<td>11.1</td>
<td>13.3</td>
</tr>
<tr>
<td>18</td>
<td>7.5</td>
<td>10</td>
<td>12.5</td>
<td>15</td>
</tr>
<tr>
<td>20</td>
<td>8.3</td>
<td>11</td>
<td>13.9</td>
<td>16.7</td>
</tr>
</tbody>
</table>

*Subtract any other infusions or calculate separately if they contain other concentrations of glucose
Appendix D Preparing glucose concentrations for infusion

How to prepare increased concentrations of glucose

<table>
<thead>
<tr>
<th>Glucose concentration required</th>
<th>10% glucose volume (100 mg/mL)</th>
<th>Glucose 50% volume (500 mg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12%</td>
<td>95 mL</td>
<td>5 mL</td>
</tr>
<tr>
<td>12.5%</td>
<td>93.75 mL</td>
<td>6.25 mL</td>
</tr>
<tr>
<td>14%</td>
<td>90 mL</td>
<td>10 mL</td>
</tr>
<tr>
<td>15%</td>
<td>87.5 mL</td>
<td>12.5 mL</td>
</tr>
<tr>
<td>16%</td>
<td>85 mL</td>
<td>15 mL</td>
</tr>
<tr>
<td>18%</td>
<td>80 mL</td>
<td>20 mL</td>
</tr>
<tr>
<td>20%</td>
<td>75 mL</td>
<td>25 mL</td>
</tr>
</tbody>
</table>

How to calculate increased concentrations of glucose

Formula to increase concentration of 10% glucose and make a 100 mL solution

\[
\frac{\text{Step 1. Volume of high concentration mL}}{\text{total volume mL} \times (\text{desired concentration}\% - \text{lower concentration}\%)} = \frac{(\text{high concentration}\% - \text{lower concentration}\%)}{\text{Step 2. Volume of low concentration mL} = \text{desired volume mL} - \text{high concentration volume mL}}
\]

Step 3. Volume of desired concentration mL = high concentration mL + low concentration mL

Example—to prepare 100 mL of 12% glucose for infusion

\[
\text{Step 1. Volume of high concentration mL} = \frac{100 \text{ mL} \times (12\% - 10\%)}{(50\% - 10\%)} = \frac{200}{40} = 5 \text{ mL}
\]

\[
\text{Step 2. Volume of low concentration mL} = 100 \text{ mL} - 5 \text{ mL} = 95 \text{ mL}
\]

\[
\text{Step 3. 100 mL} = 5 \text{ mL} (50\%) + 95 \text{ mL}(10\%)
\]

Notes:
- Glucose 50% contains 50 grams per 100 mL or 0.5 grams (or 500 mg) per 1 mL
- Glucose 10 % contains 10 grams per 100 mL or 0.1 grams (or 100 mg) per 1 mL
- Rounding final volumes of each concentration of glucose up and down may be required for practical purposes
- Remove the volume equivalent to the 50% glucose to be added from the bag of 10% glucose before adding the 50% glucose solution
### Appendix E Investigations for neonatal hypoglycaemia

<table>
<thead>
<tr>
<th>Blood samples</th>
<th>Priority</th>
<th>Volume*</th>
<th>Container guide</th>
<th>Specimen collection—during hypoglycaemic episode before treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin</td>
<td>1</td>
<td>0.5 mL</td>
<td>Red cap (serum no gel)</td>
<td>• If high haematocrit (&gt; 0.55 %)–collect additional tube</td>
</tr>
<tr>
<td>Cortisol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactate</td>
<td>1</td>
<td>0.6 mL</td>
<td>Grey cap (fluoro-oxalate)</td>
<td>• Can be measured on blood gas analyser when performing blood gas</td>
</tr>
<tr>
<td>Glucose</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acyl-carnitine profile</td>
<td>1</td>
<td>1–2 filled spots OR 0.5 mL</td>
<td>Newborn screening card OR Green cap (lithium heparin)</td>
<td>• Label card Acyl-carnitine profile</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In addition to newborn screening test (NST)—send routine NST as usual</td>
</tr>
<tr>
<td>Blood gas including: Electrolytes</td>
<td>1 (or 3)</td>
<td>0.5 mL</td>
<td>Blood gas syringe or capillary tube OR Red cap (serum no gel)</td>
<td>• Can be done with blood gas, lactate and glucose if done in blood gas machine as priority 1</td>
</tr>
<tr>
<td>Haemoglobin</td>
<td>1 (or 3)</td>
<td></td>
<td></td>
<td>• Send specimen on ice to laboratory to prevent metabolism of glucose by red cells on route</td>
</tr>
<tr>
<td>Haematocrit</td>
<td>1 (or 3)</td>
<td></td>
<td></td>
<td>• Priority 3 if not done in blood gas machine</td>
</tr>
<tr>
<td>Electrolytes/liver function tests</td>
<td>3</td>
<td>1 mL</td>
<td>Red cap (serum no gel)</td>
<td>• If liver function tests only collect 0.5 mL</td>
</tr>
<tr>
<td>Growth hormone</td>
<td>2</td>
<td>0.5 mL</td>
<td>Red cap (serum no gel)</td>
<td>• On ice, preferably less than 1 hour to the laboratory</td>
</tr>
<tr>
<td>Beta hydroxybutyrate</td>
<td>3</td>
<td>0.4 mL</td>
<td>Red cap (serum no gel)</td>
<td></td>
</tr>
<tr>
<td>Adrenocorticotropic hormone</td>
<td>As advised</td>
<td>0.4 mL</td>
<td>Pink/purple cap (EDTA*)</td>
<td></td>
</tr>
<tr>
<td>Plasma amino acid profile</td>
<td>3</td>
<td>0.5 mL</td>
<td>Green cap (lithium heparin)</td>
<td></td>
</tr>
<tr>
<td>Ammonium</td>
<td>3</td>
<td>0.5 mL</td>
<td>Pink/purple cap (EDTA*)</td>
<td>• Notify laboratory and send urgently. If any delay put on ice</td>
</tr>
<tr>
<td>Pyruvate</td>
<td>3</td>
<td>0.5 mL</td>
<td></td>
<td>• Contact pathology service prior to collection for perchlorate tube</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Urine sample</th>
<th>Specimen collection—first specimen after hypoglycaemic episode (critical sample)</th>
</tr>
</thead>
</table>
| Metabolic screen | 1 | 10 mL (or available volume from one sample) | Yellow lid specimen container | • Treatment can start while collecting specimen  
• Store and transport at 4 ºC |

*EDTA–Ethylenediaminetetraacetic acid (anticoagulant used in blood collection)
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