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Review

Hypoglycemia in Breastfed Neonates

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ABSTRACT

Healthy, full-term infants are programmed to make the transition from their intrauterine constant flow of nutrients to their extrauterine intermittent nutrient intake without the need for metabolic monitoring or interference with the natural breastfeeding process. Homeostatic mechanisms ensure adequate energy substrate is provided to the brain and other organs, even when feedings are delayed. The normal pattern of early, frequent, and exclusive breastfeeding meets the needs of healthy full-term infants. Routine screening or supplementation are not necessary and may harm the normal establishment of breastfeeding. Screening should be restricted to at-risk and symptomatic infants. Symptomatic infants need immediate assessment and intravenous glucose therapy, not forced feedings.

INTRODUCTION

In the last issue of *Breastfeeding Medicine*, the Academy of Breastfeeding Medicine published its updated Clinical Protocol #1: *Guidelines for Glucose Monitoring and Treatment of Hypoglycemia in Breastfed Neonates*.[1] This revised protocol was based on an extensive review of the literature, but because of the nature of a protocol, not all the background information and supporting documentation could be included. This article provides much of the information in the protocol, but also additional discussion and references that may be of value to clinicians seeking to establish effective and breastfeeding-supportive care of neonates who have, or are at risk for, hypoglycemia.

GLUCOSE HOMEOSTASIS DURING TRANSITION

Throughout gestation the fetus receives its entire supply of glucose (70% of its energy needs) from the maternal circulation by facilitated diffusion via the placenta, with fetal plasma glucose levels 70% to 80% of maternal venous plasma levels.[2] Glucose utilization by the fetus is approximately 5 mg/kg per minute with amino acids and lactate as additional energy sources.[2] Although present, the enzyme activity necessary for gluconeogenesis is minimal in the fetus as there is no need for glucose production. However, an important sequence of integrated metabolic adaptations occurs at birth, allowing the newborn to produce glucose

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and regulate its own metabolic homeostatic processes.[3] At birth the infant must supply its glucose needs of approximately 5 to 8 mg/kg per minute (70% used by the brain) through a balance of exogenous sources (breast milk) and endogenous glucose production through gluconeogenesis, glycogenolysis, and ketogenesis, provided adequate substrates are available.[3,4]

Within minutes of cutting the umbilical cord, there is a three- to fivefold surge in glucagon and catecholamines, which initiate glycogen breakdown. High endogenous growth hormone and cortisol facilitate the onset of gluconeogenesis within several hours, and insulin secretion is blunted so that serum concentrations of insulin fall.[3] The processes that ensure the availability of glucose and other fuels are collectively described as counter-regulation, and are activated primarily by glucagon and adrenalin.[3]

The term *hypoglycemia* refers to a low blood glucose concentration. Neonatal hypoglycemia is not a medical condition in itself, but a feature of illness or a failure to adapt from the fetal state of continuous transplacental glucose consumption to the extrauterine pattern of intermittent nutrient supply.[2] Transient hypoglycemia in the immediate newborn period is common and occurs in almost all mammalian species. In healthy term human infants, even if early enteral feeding is withheld, this phenomenon is self-limited as glucose levels spontaneously rise within 2 to 3 hours.[5–7] This early self-limited period of hypoglycemia cannot be considered pathologic, and there is little practical value in measuring the blood glucose concentrations of asymptomatic babies in the first 2 hours after birth.[2,4,8] Furthermore, even in those situations in which low blood glucose concentrations develop secondary to prolonged intervals (>8 hours) between breast feedings,[6] there is a marked ketogenic response that provides glucose-sparing fuel to the brain.[6,9–11] The neonatal brain has an enhanced capability to use ketone bodies relative to infants (fourfold) and adults (40-fold).[12]

Hawdon[6] and others have studied this pattern of metabolic adaptation.[13,14] Breastfed term infants have lower blood glucose[6,13–15] and higher ketone bodies[6] than formula-fed infants. Breastfed infants up to 1 week old had a significantly lower mean blood glucose concentration (range 1.5 to 5.3 mmol/L [27 to 95 mg/dL] and mean 3.6 mmol/L [58 mg/dL]) than formula-fed infants of the same age (range 2.5 to 6.2 mmol/L [45 to 111 mg/dL] and mean 4.0 mmol/L [72 mg/dL]).[6] Those infants who lost the most weight postnatally had the highest ketone body concentrations,[6] which suggests that the provision of alternate fuels constitutes a normal adaptive response to transiently low nutrient intake during the establishment of breastfeeding.[6,16] Because the optimally breastfed infant's lower blood glucose is the physiologic norm, it has been suggested that breastfed infants may well tolerate lower plasma glucose levels without any significant clinical manifestations or sequelae, assuming adaptive metabolic response systems are functioning normally.[16] One case series of hypoglycemia in "healthy, breastfed term newborns" (all of whom were feeding poorly at discharge) revealed no urinary ketones in any of the three symptomatic infants, suggesting a defective ketogenic response to fasting.[17]

As yet there has been no systematic study of *urinary* ketones in symptomatic or asymptomatic hypoglycemic newborns. The presence of urinary ketones may prove to be a reassuring finding in asymptomatic, mildly to moderately hypoglycemic infants. Multiple regression analysis from Hawdon's study,[6] correcting for postnatal age and feeding method, revealed that only the interval between feeds was inversely correlated with glucose concentration, supporting the need for continuous mother–infant contact and frequent on-demand nursing.

DEFINITIONS OF HYPOGLYCEMIA

The definition of hypoglycemia in the newborn infant has remained controversial because of a lack of significant correlation among plasma glucose concentration, clinical symptoms, and long-term sequelae.[16,18–20] There have been four main approaches to the definition of hypoglycemia: (a) epidemiologic/statistical approach based on measured range of glucose values; (b) clinical manifestations; (c) acute changes in metabolic/endocrine re-

sponses and neurologic function; and (d) long-term neurologic outcome.[2,16]

Epidemiologic approach

"Normal" blood glucose results vary enormously with the source of the blood sample, assay method, and whether blood or plasma glucose concentration is determined. Plasma or serum glucose concentrations are 10% to 15% higher than in whole blood.[21] In addition, early feeding schedules have a prominent effect on blood glucose concentrations but have changed a great deal since early studies.[2] Even now they vary from hospital to hospital. The healthy, term exclusively breastfed infant represents the biological norm, yet until recently, very few breastfed infants had been studied.

Breastfed, formula-fed, and mixed-fed infants follow the same pattern of glucose values with an initial fall in glucose over the first 2 hours, followed by a gradual rise in glucose over the next 96 hours, whether fed or not (Table 1).[5,14,22] As noted, when compared, breastfed infants tend to have slightly lower glucose and higher ketone bodies than artificially fed infants.[6,13–15] Although helpful, the findings of the epidemiologic approach have been erroneously used to define the cutoff between normoglycemia and hypoglycemia rather than recognizing that hypoglycemia reflects a continuum of biologic abnormalities, ranging from mild to severe.[16]

The incidence of "hypoglycemia" varies with the definition.[25] Many authors have suggested numeric definitions of hypoglycemia, usually between 30 and 50 mg/dL (1.7 to– 2.8 mmol/L)

Table 1. Neonatal Blood Glucose Concentration (mg/dL-top, and mmol/L-bottom) in Term Infants by Postnatal Age from Seven Survey Studies

Age (h)	*Srinivasan 1986*[5] *Plasma: mixed fed (mean ± SD)*	*Heck 1987*[14] *Serum: mixed fed (mean ± SD)*	*Hawdon 1992*[6] *Whole blood: mixed fed (mean ± SD)*	*Swenne 1994*[13] *Serum: breastfed (mean ± SD)*	*Hoseth 2000*[22] *Whole blood: breastfed median (10–90 percentile)*	*Adejuyigbe 2001*[23] *Plasma: breastfed (mean ± SD)*	*Diwaker 2002*[24] *Plasma: breastfed (mean ± SD)*
0	107 ± 35	97 ± 29	65 ± 2	—	88 (50–128)	64 ± 32	—
1	56 ± 19	60 ± 18	—	—	50 (36–70)	—	—
2	60 ± 11	61 ± 15	—	—	56 (36–81)	—	—
3	70 ± 13	—	—	38 ± 9.5	—	—	54 ± 19
4	68 ± 14	—	—	(3–15 h)	54 (47–70)	—	—
6	65 ± 13	56 ± 11	—	—	50 (40–61)	—	53 ± 13.5
12	67 ± 14 (12–24 h)	56 ± 12	58 ± 5.4	—	50 (41–63)	—	—
24	71 ± 10 (25–48 h)	61 ± 10	63 ± 3.6	53 ± 9.7	50 (41–63)	57 ± 15	52 ± 14
48	73 ± 13 (49–72 h)	64 ± 10	63 ± 3.6	—	63 (58–79)	59 ± 17	—
72	83 ± 12 (73–96 h)	—	61 ± 2	—	61 (52–83)	—	54 ± 14
96	80 ± 12 (97–168 h) mmol/L	—	74 ± 2	—	68 (58–81)	—	
0	5.94 ± 1.94	5.4 ± 1.6	3.6 ± 0.1	—	4.9 (2.8–7.1)	3.55 ± 1.76	—
1	3.1 ± 1.06	3.3 ± 1	—	—	2.8 (2–3.9)	—	—
2	3.3 ± 0.61	3.4 ± 0.83	—	—	3.1 (2–4.5)	—	—
3	3.9 ± 0.72	—	—	2.1 ± 0.53	—	—	3 ± 1.05
4	3.8 ± 0.78	—	—	(3–15 h)	3 (2.6–3.9)	—	—
6	3.6 ± 0.72	3.1 ± 0.61	—	—	2.8 (2.2–3.4)	—	2.95 ± 0.75
12	3.7 ± 0.78	3.1 ± 0.67	3.2 ± 0.3	—	2.8 (2.3–3.5)	—	—
24	3.9 ± 0.56	3.4 ± 0.56	3.5 ± 0.2	2.93 ± 0.54	2.8 (2.3–3.5)	3.18 ± 0.85	2.89 ± 0.79
48	4.1 ± 0.72	3.6 ± 0.56	3.5 ± 0.2	—	3.5 (3.2–4.4)	3.29 ± 0.967	—
72	4.6 ± 0.67	—	3.4 ± 0.1	—	3.4 (2.9–4.6)	—	3 ± 0.79
96	4.4 ± 0.67	—	4.1 ± 0.1	—	3.8 (3.2–4.5)	—	—

and varying by postnatal age.[2,5,14,18,25–29] Cornblath et al.[16] summarized the problem well: "Significant hypoglycemia is not and can never be defined as a single number that can be applied universally to every individual patient. Rather, it is characterized by a value(s) that is unique to each individual and varies with both their state of physiologic maturity and the influence of pathology." Instead of specifying a number to represent hypoglycemia, Cornblath et al.[16,30] suggest "operational thresholds" as defined by Table 2. These "operational thresholds" represent values to which one should react, either by further testing and/or treatment. They do not represent either normal or abnormal values.

A recent metaanalysis (studies published 1986 to 1994) of low plasma glucose thresholds in full-term normal newborns who were mostly mixed fed (formula and breastfeeding) or formula fed, presented recommended low thresholds for plasma glucose based on hours after birth (Table 3). They specifically noted that given the lower plasma glucose levels in normal breastfed infants, the low thresholds for exclusively breastfed infants might even be lower.[31]

Clinical manifestations of hypoglycemia

The clinical manifestations of hypoglycemia are *nonspecific*, occurring with a variety of other neonatal problems. Even in the presence of an arbitrary low glucose level, the physician must assess the general status of the infant by observation and physical examination to rule out other disease entities and processes that may need additional laboratory evaluation and treatment. Some common clinical signs are listed in Table 4. A diagnosis of hypoglycemia also requires that symptoms abate after normoglycemia is restored.

Acute physiologic changes

Neurophysiologic monitoring, including electroencephalography (EEG), visual evoked potentials (VEP), and brainstem auditory evoked responses (BAER) have failed to define a safe blood glucose concentration or a threshold for neurologic damage.[4] Koh et al.[32] reported BAER abnormalities only when blood glucose fell below 2.6 mmol/L (47 mg/dL). Unfortunately, only 5 of their 17 patients were less than 4 days old, only one was symptomatic, and the symptoms did not correlate with the lowest blood glucose level. Kinnala et al.[33] found four times the number of head MRI and ultrasound abnormalities in 18 *symptomatic* full-term infants than 19 normoglycemic controls. Most lesions were absent by 2 months of age, and only one infant appeared neurologically affected.

Evidence from tissue culture and animal models indicate that the neural damage attrib-

Table 2. Operational Thresholds

Operational threshold	*Plasma glucose*
Intervention	<36 mg/dL (2.0 mmol/L)
Intravenous glucose	<20–25 mg/dL (1.1–1.4 mmol/L)
Preterm infants	Same as term
Infants on TPN	>45 mg/dL (2.5 mmol/L)
Therapeutic objective	
Transient hypoglycemia	>45 mg/dL (2.5 mmol/L)
Profound/persistent hypoglycemia	>60 mg/dL (3.3 mmol/L)
Operational threshold by age after birth	
1st 24 h	
Healthy term or preterm 34–37 wk, formula-fed	<30–35 mg/dL (1.7–2.0 mmol/L)
Sick, LBW, preterm <34 wk	<45–50 mg/dL (2.5–2.8 mmol/L)
>24 h	<40–50 mg/dL (2.2–2.8 mmol/L)
Any age	20–25 mg/dL (1.1–1.4 mmol/L)

From: Cornblath M, Hawdon JM, Williams AF, et al. Controversies regarding definition of neonatal hypoglycemia: Suggested operational thresholds. *Pediatrics* 2000;105:1141–1145; Cornblath M, Ichord R. Hypoglycemia in the neonate. *Semin Peinatol* 2000;24:136–149.

Table 3. Recommended Low Thresholds: Plasma Glucose Level

Hour after birth	*≤5th Percentile PGL-mg/dL (mmol/L)*
1–2 (nadir)	28 (1.6)
3–47	40 (2.2)
48–72	48 (2.7)

From: Alkalay AL, Sarnat HB, Flores-Sarnat L, et al. Population meta-analysis of low plasma glucose thresholds in full-term normal newborns. *Am J Perinatol* 2006;23:115–119.

uted to hypoglycemia is not simply a matter of inadequate energy stores, but rather a result of accumulation of toxic substances, such as aspartic acid[4] and glutamate.[34] Because this process requires time (hours to days), clinicians can be reassured that transient, single, brief periods of hypoglycemia are unlikely to cause permanent neurologic damage.[4,34,35]

Long-term neurologic outcome

The data correlating neonatal hypoglycemia with long-term neurologic outcome are limited because of lack of suitable nonhypoglycemic controls, a failure to consider other pathology, and the small number of asymptomatic infants followed.[16,19,20] Animal studies suggest that the immature brain is incredibly resistant (via many different mechanisms) to damage from even profound hypoglycemia.[36] Koivisto et al.[37] found no difference in neurologic outcome between asymptomatic hypoglycemic infants and euglycemic control infants, with 94% and 95% of each group normal on 1- to 4-year follow-up. There was a significant increase in neurologic abnormalities (12%) in *symptomatic* (tremor, cyanosis, paleness, limpness, irritability, apathy, or tachypnea that disappeared during treatment with glucose) hypoglycemic infants, and 50% incidence of neurologic abnormalities when seizures were present. The estimated duration of hypoglycemia was 37 hours in the asymptomatic hypoglycemic infants, 49 hours in the symptomatic/nonseizure group, and 105 hours in the seizure group. The follow-up evaluation included a physical examination, anthropometry, and neurologic and developmental assessments, as well as an ophthalmologic examination. Interestingly, this study was done in Finland from 1967 to 1970, at a time when infants were fed 5% "saccharose" for 24 hours prior to initiating breastfeeding.

More recently, Brand et al.[38] studied hypoglycemia (defined as <2.2 mmol/L [<40 mg/dL] 1 hour after birth or <2.5 mmol/L [<45 mg/dL] thereafter) in term LGA infants born to nondiabetic mothers. Screening was done at 1, 3, and 5 hours after birth and continued if the glucose was low. Intravenous glucose was started if the glucose was less than 1.5 to 2 mmol/L (27 to 36 mg/dL) or symptoms were present. There were no significant differences between the hypoglycemic and control groups at 4-year follow-up, which consisted of the Dutch version of the Denver Developmental Scale, the Snijders-Oomen nonverbal intelligence test, and the Dutch version of the Child Behavior Check List. Unfortunately, the type of feeding was not disclosed and only 64% of the original population completed the assessment at 4 years.

A recent systematic review of cohort studies on subsequent neurologic development after episodes of hypoglycemia in the first week of life found that major clinical and methodologic heterogeneity of available studies precluded any true metaanalysis.[20] Of the 18 eligible studies, the overall methodologic quality was considered poor in 16 studies and high in two studies. Pooling of the results of the two high-quality studies was deemed inappropriate because of this heterogeneity. None of the studies provided a valid estimate of the effect of neonatal hypoglycemia on neurodevelopment. Building on the strengths and weaknesses of existing studies, they proposed an "optimal" future study design and invited content experts and clinicians worldwide to comment, refine the design, and

Table 4. Clinical Manifestations of Possible Hypoglycemia

Irritability, tremors, jitteriness
Exaggerated Moro reflex
High-pitched cry
Seizures or myoclonic jerks
Lethargy, listlessness, limpness, hypotonia
Coma
Cyanosis
Apnea or irregular breathing
Tachypnea
Hypothermia
Vasomotor instability
Poor suck or refusal to feed

participate in a prospective collaborative study. Hopefully, such a study will be done.

In the absence of definitive data regarding a "safe" blood glucose concentration in any given population, the "operational threshold" approach suggested by Cornblath[16,30] and Alkalay[31] seems most appropriate. Hawdon[39] summarized it well: "Evidence from studies of humans and other animals suggests that cortical damage and long-term sequelae occur after prolonged hypoglycemia sufficiently severe to cause neurological signs."

ASSESSMENT OF GLUCOSE LEVELS

Bedside glucose testing strips are inexpensive and practical, but are not reliable with significant variance from true blood glucose levels.[29,40,41] Studies comparing different reagent strips have estimated that as many as 20% of truly normoglycemic infants are falsely labeled as hypoglycemic, leading to unnecessary laboratory tests and treatment.[4] A recent study evaluated readily available "point-of-care" glucose measuring devices and concluded that none of the five glucometers was satisfactory as the sole measuring device.[34] Newer bedside glucose systems simplify procedures, but appropriate test strip storage, handling, and adherence to expiration dates are still essential to prevent error.[42]

Even newer point-of-care glucose electrode (YSI) and cuvette-based glucose oxidation optical methods (HemoCue), although possible improvements over reagent strips, do not have the reliability of laboratory measurement.[2,43–45] Bedside glucose tests may be used for screening, but laboratory levels must confirm results before a diagnosis of hypoglycemia can be made, especially in asymptomatic infants.[2,21,35,40]

RISK FACTORS FOR HYPOGLYCEMIA

Neonates at increased risk for developing neonatal hypoglycemia should be routinely monitored for blood glucose levels irrespective of the mode of feeding. These at-risk infants should be screened *before* any symptoms manifest. Neonates at risk fall into two main categories: (a) Excess use of glucose, which includes the hyperinsulinemic states; and (b) inadequate production or substrate delivery.[30] Table 5 shows infant categories at increased risk for hypoglycemia.[4,16,30,46–48]

MANAGEMENT RECOMMENDATIONS

General

Glucose screening should be performed only on at-risk infants and those with clinical symptoms compatible with hypoglycemia. Routine monitoring of blood glucose in asymptomatic, term newborns is potentially harmful to the establishment of a healthy mother–infant relationship and successful breastfeeding patterns.[2,4,8,35,40,49–54] This recommendation has been supported by the World Health Organization,[2] the AAP,[51] and the National Childbirth Trust of the United Kingdom.[52] At-risk infants should be screened for hypoglycemia with a frequency and duration related to the specific risk factors of the individual infant.[4] It is suggested that monitoring begin within 30 to 60 minutes of age for infants with suspected hyperinsulinemia, and no later than 2 hours of age for infants in other risk categories. Monitoring should continue, until normal preprandial levels are consistently obtained. Bedside glucose screening, tests must be confirmed by formal laboratory testing.

Early and exclusive breastfeeding meets the nutritional needs of healthy, term, newborn infants. Healthy term infants do not develop symptomatic hypoglycemia simply as a result of underfeeding.[2,4,51] Therefore, routine supplementation of healthy, term infants with water, glucose water, or formula is unnecessary and may interfere with establishment of normal breastfeeding and normal metabolic compensatory mechanisms.[6,13,51,52] As with general breastfeeding recommendations, healthy term infants should initiate breastfeeding within 30 to 60 minutes of life and continue on demand, recognizing that crying is a very late sign of hunger.[51,55] Feedings should be frequent, 10 to 12 times per 24 hours in the first few days after birth.[51] Early breastfeeding is

Table 5. At-Risk Infants for Whom Routine Monitoring of Blood Glucose Is Indicated

Small for gestational age (SGA); <10th percentile for weight
Large for gestational age (LGA); >90th percentile for weight*
Discordant twin; weight 10% < larger twin
Infant of diabetic mother, especially if poorly controlled
Low birth weight (<2500 g)
After perinatal stress; severe acidosis or hypoxia-ischemia
Cold stress
Polycythemia (venous Hct > 70%)/hyperviscosity
Erythroblastosis fetalis
Beckwith-Wiedemann syndrome
Microphallus or midline defect
Suspected infection
Respiratory distress
Known or suspected inborn errors of metabolism or endocrine disorders
Maternal drug treatment (e.g., terbutaline, propranolol, oral hypoglycemics)
Infants displaying symptoms associated with hypoglycemia (see Table 4)

*In unscreened populations in which LGA may represent undiagnosed and untreated maternal diabetes.

not precluded just because the infant meets the criteria for glucose monitoring. Initiation and establishment of breastfeeding is also facilitated by skin-to-skin contact of mother and infant. Such practices will maintain normal infant body temperature and reduce energy expenditure while stimulating suckling and milk production.[15,51]

Documented hypoglycemia in an asymptomatic infant

As noted, the asymptomatic "hypoglycemic" infant is at extremely low risk of long-term neurologic sequelae. Such an infant should continue breastfeeding (approximately every 1 to 2 hours) or feed 3 to 5 mL/kg of expressed breast milk or substitute nutrition (pasteurized donor human milk, elemental formulas, partially hydrolyzed formulas, or routine formulas). This volume is based on normal volumes of colostrum[56] and the average size of the infant's stomach in the first week postpartum.[57] There is no research available delineating what amount of glucose or what volume of glucose-containing oral fluids is needed to raise serum glucose a certain amount in any population.

The blood glucose concentration should be rechecked before subsequent feedings until the value is acceptable and stable. If the neonate is unable to suck or feedings are not tolerated, avoid forced feedings (e.g., nasogastric tube) and begin intravenous therapy (see the following). Such an infant is not normal and requires a careful examination and evaluation in addition to more intensive therapy. If glucose remains low despite feedings, intravenous glucose therapy should be initiated and intravenous rate adjusted by blood glucose concentration. Of course breastfeeding may continue during intravenous (IV) glucose therapy if the infant is interested and will suckle. As with any medical therapy, clinical signs, physical examination, screening values, laboratory confirmation, treatment, and changes in clinical condition (i.e., response to treatment) should be carefully documented.

Symptomatic hypoglycemic infants

Infants with symptoms consistent with hypoglycemia (see Table 4) or infants with plasma glucose levels less than 20 to 25 mg/dL (<1.1 to 1.4 mmol/L) should have more aggressive therapy. Current neonatal texts suggest initiating intravenous glucose using a 2 mL/kg bolus of 10% glucose solution, followed by a continuous infusion of 6 to 8 mg/kg per minute (approximately 80 to 100 mL/kg per 24 hours).[58] Attempts to rely on oral or intragastric feeding to correct extreme (<20 to 25 mg/dL) or symptomatic hypoglycemia are inappropriate and may be dangerous if the infant aspirates the oral supplement. Such an infant is not normal and requires an immediate and careful examination and evaluation. To allow for minute-to-minute variations in blood glucose, the glucose

concentration in symptomatic infants should be maintained at greater than 45 mg/dL (>2.5 mmol/L).

The intravenous rate should be adjusted by blood glucose concentration and frequent breastfeeding should be encouraged after the relief of symptoms. As feedings are initiated, glucose concentrations should be monitored before feedings as the IV is weaned, until values are stabilized off intravenous fluids. Again, clinical signs, physical examination, screening values, laboratory confirmation, treatment, and changes in clinical condition (i.e., response to treatment) should be carefully documented.

SUPPORTING THE MOTHER

Having an infant thought to be normal and healthy develop hypoglycemia is both concerning to the mother and family, and may jeopardize breastfeeding. Mothers should be reassured that there is nothing wrong with their milk, and that supplementation is usually temporary. Having the mother hand express or pump milk that is then fed to her infant can overcome feelings of maternal inadequacy as well as help establish a full milk supply. In order to protect the mother's milk supply, it is important to provide stimulation to the breasts by manual or mechanical expression with appropriate frequency (8 times in 24 hours) until her baby is latching and suckling well. Keeping the infant at the breast or returning the infant to the breast as soon as possible is important. Skin-to-skin care is easily done with an IV and may soften the trauma of intervention, while providing physiologic thermoregulation, contributing to metabolic homeostasis.

FUTURE RESEARCH

Boluyt et al.[20] proposed a study design to answer two questions: (a) What is the effect of various blood glucose concentrations in the first three postnatal days on long-term neurodevelopment? and (b) What is the effect of treatment with additional carbohydrates in neonates with moderate hypoglycemia on long-term neurodevelopment compared with expectant observation? In addition, the development of simple, rapid, and reliable bedside testing would improve the efficiency of diagnosis and treatment. A clearer understanding of the role of other metabolic fuels and methods to measure them in a clinically useful way may improve the ability to predict which infants are truly at risk for neurologic sequelae, and facilitate more rapid and appropriate treatment. Finally, it is unclear how much enteral glucose in what form is necessary to raise blood glucose to acceptable levels, once those levels are determined. At present, many breastfed infants are being grossly overfed with the good intention of avoiding intravenous glucose. It may be that more long-term problems are being caused by aggressively feeding artificial milks.

CONCLUSION

Healthy, full-term infants are programmed to make the transition from their intrauterine constant flow of nutrients to their extrauterine intermittent nutrient intake without the need for metabolic monitoring or interference with the natural breastfeeding process. Homeostatic mechanisms ensure adequate energy substrate is provided to the brain and other organs, even when feedings are delayed. The normal pattern of early, frequent, and exclusive breastfeeding meets the needs of healthy full-term infants. Routine screening or supplementation are not necessary and may harm the normal establishment of breastfeeding. Screening should be restricted to at-risk and symptomatic infants. Symptomatic infants need immediate assessment and intravenous glucose therapy, not forced feedings.

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APPENDIX A

To convert mmol/L of glucose to mg/dL, multiply by 18.
To convert mg/dL of glucose to mmol/L, divide by 18 or multiply by 0.055.