



Neonatal Hypoglycemia

When should you treat?



**Texas Children's
Hospital®**

Dr. Sharon Fassino, DNP, RN, NNP-BC

No financial disclosure

Objectives:

- By the end of this presentation, the participant will:
 - Gain an understanding of hypoglycemia in the newborn.
 - Identify neonates at risk for hypoglycemia during the immediate newborn period.
 - Describe the signs and symptoms of hypoglycemia in the neonate.
 - Identify the treatment for asymptomatic and symptomatic hypoglycemia in the neonate.

Trivia



**Texas Children's
Hospital®**

- Hypoglycemia has been documented as far back as 150 AD by a Greek physician known as Arateus
- Diabetic symptoms were described in 1552 in Egypt
- Officially named “Diabetes Mellitus” in 1675
- Chemical test created in 1800’s to identify the existence of sugar in urine
- 1916: Elliott Joslin wrote *The Treatment of Diabetes Mellitus* which is still used today to teach patients the basics of diabetes and lifestyle changes.

- 1st incubator used in 1857 by Jean Louis Paul Denucé.
- Infant Welfare Movement (IWM) began in 1870 in Europe to decrease infant mortality.
- IWM moved to United States in 1896.
- Early 1900's saw the introduction of artificial feeding when breastfeeding was unavailable
 - Artificial feeding included milk, cream, and sugar
- 1922: 1st unit for premature infants at Sarah Morris Hospital in Chicago
- Neonatal hypoglycemia first reported in 1937

Lusky, 1999

General Information



**Texas Children's
Hospital®**

History

- Early 1900's: signs of hypoglycemia were first reported
- 1920's low blood sugar was felt to be physiologic
- 1930's: adopted clinical definition based on neonatal symptoms

Hawkes & Stanley, 2016

History

- 1960's: began to define hypoglycemia based on normal values in the general population
- 2000's: Returned to definition of hypoglycemia based on physiological signs and symptoms with an interventional threshold used to guide decision making

Hawkes & Stanley, 2016

Definition

- Hypoglycemia occurs when plasma glucose levels decrease leading to signs and symptoms of impaired brain function.
 - Numerical definitions for hypoglycemia still remain controversial depending on context
 - “Operational threshold” is defined as the concentration of plasma or whole blood glucose at which clinicians should consider intervention. (Chandran, Rajadurai, Alim, & Hussain, 2014)

Hawkes & Stanley, 2016

Definition

- Categories of hypoglycemia
 - Mild: 35 – 45 mg/dl
 - Moderate: 25 – 35 mg/dl
 - Profound: < 25 mg/dl

Hawkes & Stanley, 2016

Definition

Newborn period:

- Transient neonatal hypoglycemia
 - 1st 24 hours of life: plasma level < 30 mg/dl
 - 24 hours of life or greater: plasma level < 48 mg/dl
- Persistent hypoglycemia
 - Persisting beyond 48 hours of life

Glucose level <36 mg/dl in 1st 4 hours of life

- There is no specific “cut off” level which would prevent brain injury
- Symptoms can and do occur across a range of plasma levels
- Altered brain responses can be impacted by alternative fuels such as ketones

Hawkes & Stanley, 2016

General Information

Overall incidence of symptomatic hypoglycemia is 1 – 3 per 1000 live births.

Most common metabolic problem in neonates.

Most infants with hypoglycemia are either asymptomatic or only exhibit non-specific signs and symptoms.

Cranmer, 2018; Su & Wang, 2012

General Information

Persistent and recurrent hypoglycemia can severely impair brain growth and function

While both term and preterm infants can have neurological effects at glucose levels of 45, preterm infants are more likely to have adverse, irreversible neurological injury compared to term infants.

Cranmer, 2018; Su & Wang, 2012

At Risk

- Birth weight < 2 kg or > 4 kg
- Large for gestational age (LGA)
- Small for gestational age (SGA)
- Intrauterine growth restriction (IURG)
- Neonates of insulin-dependent mother (1:1000 pregnant women)
- Mothers with gestational diabetes (~2% of pregnant women)
- Preterm or Late Preterm neonates
- Suspected of sepsis or chorioamnionitis

At Risk

- Significant hypoxia
- Perinatal distress
- 5 minute Apgar 5 or less
- Hypothermia
- Isolated hepatomegaly
- Microcephaly
- Multiple congenital anomalies
- Suspected inborn error of metabolism
- Maternal history of terbutaline, beta blockers, or oral hypoglycemic medications

Pathophysiology



**Texas Children's
Hospital®**

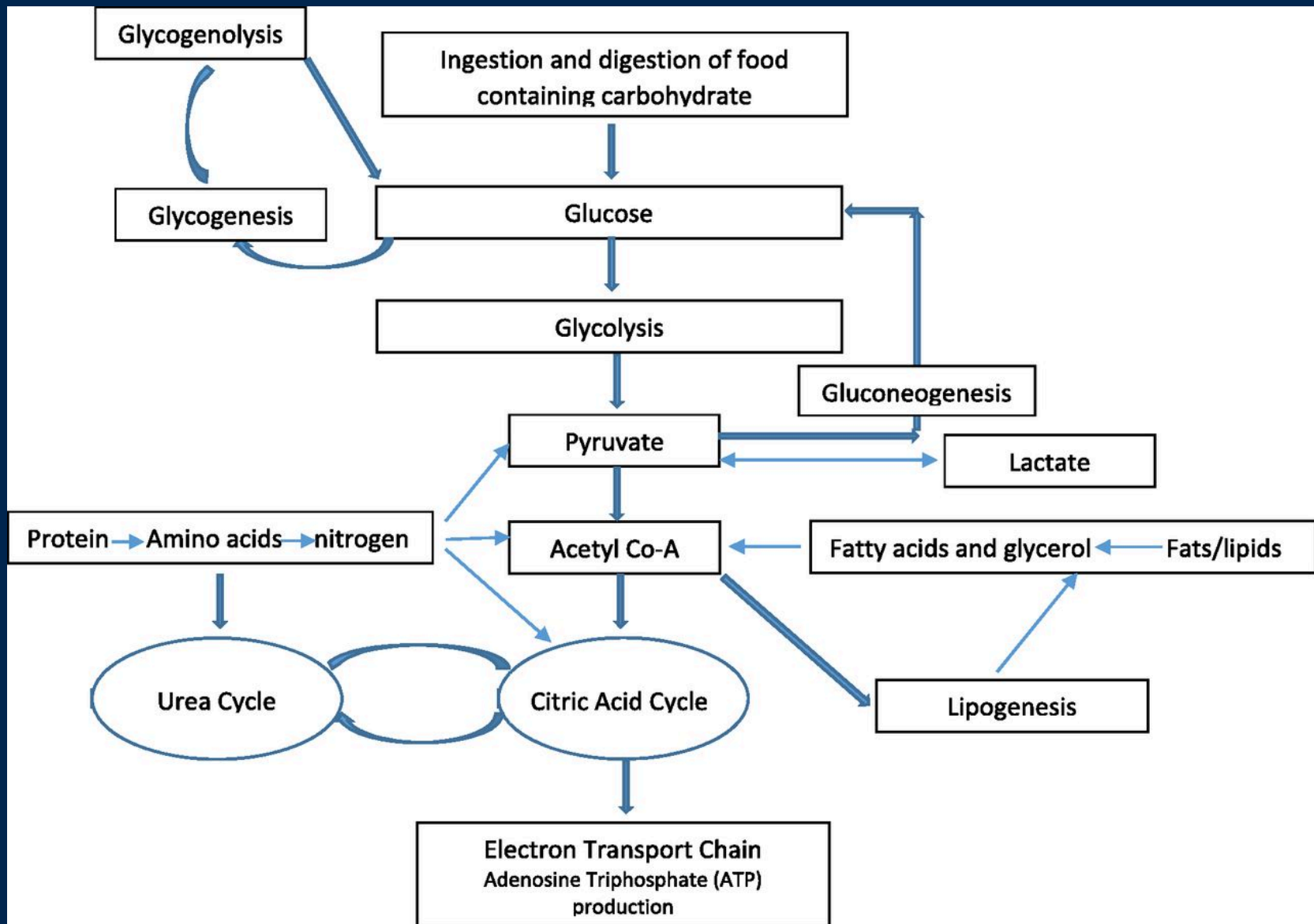
Glucose

Fetal storage of glucose occurs primarily in the 3rd trimester in the form of glycogen

- ~ 70 – 80% of maternal glucose levels can be seen in fetus during pregnancy

After birth

- Glycogen is broken down into glucose molecules which are released back into the blood stream to be used as energy



Thompson-Branch &
Havranek, 2017

Causes of Hypoglycemia

- Inappropriate changes in hormone secretion
- Inadequate substrate reserve
 - Hepatic glycogen
- Inadequate muscle stores
 - Source of amino acids for gluconeogenesis
- Inadequate lipid stores
 - Release of fatty acids

Pathophysiology

- Hormones which regulate glucose levels
 - Insulin
 - Glucagon
- How does it work?
 - Insulin is secreted after food intake to increase insulin levels
 - Insulin stimulates liver to store glucose as glycogen
 - When muscle/liver cells are saturated with glycogen extra glucose is stored as fat
 - When glucose levels fall
 - Glycogen is secreted to increase glucose levels through glycogenolysis
 - Glycogenolysis releases glucose back into the blood

Pathophysiology

- After birth

- Serum glucose levels decline during the 1st 3 hours after birth then begin to stabilize
- Should reach nadir level ~ 1 hour after birth
- Glycogen stores in the liver rapidly deplete within 1st 12 hours of life.
- Glucose starts to increase spontaneously after 3 hours of life.
- Gluconeogenesis accounts for ~10% of glucose usage by the neonate by several hours of age.

Pathophysiology

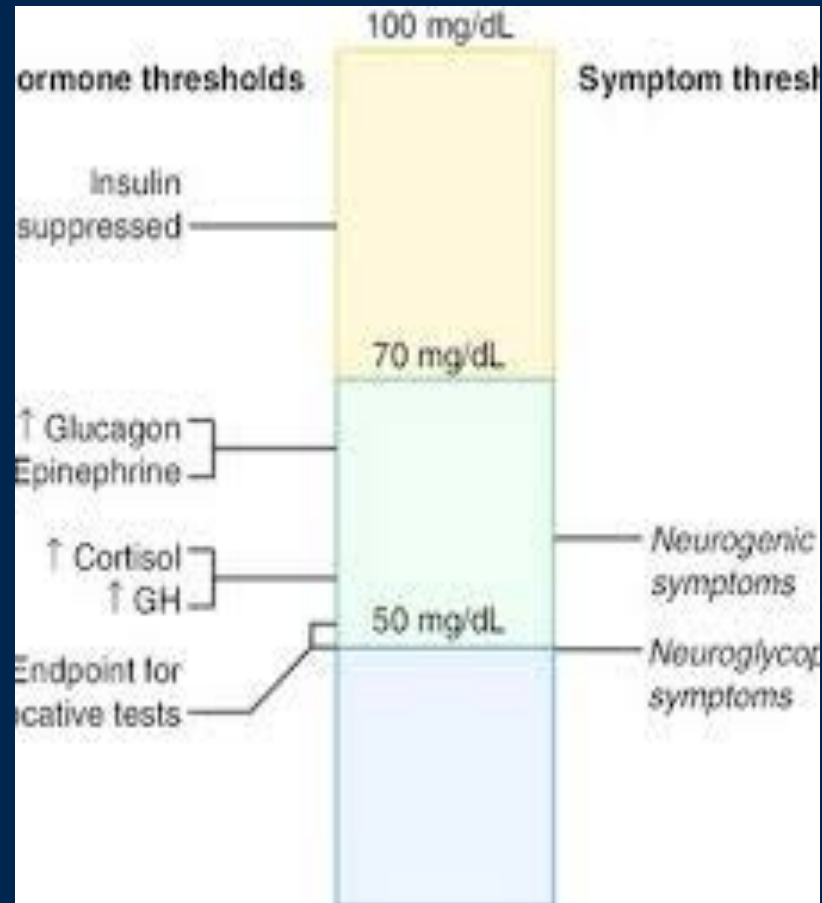
Gluconeogenesis is defined as “the formation of glucose from amino acids and the glycerol portion of fat. Muscle provides a store of glycogen and muscle protein breaks down to amino acids, which are substrates utilized in gluconeogenesis in the liver.”

Cranmer, 2018

Pathophysiology

Glucose is the major fuel for brain functions/ metabolism

Response to hypoglycemia is hormonal (insulin suppression) and metabolic (gluconeogenesis)



Cranmer, 2018; Hawkes & Stanley, 2016

Pathophysiology

- Hypoglycemia can lead to changes such as “brain cell softening, swelling, necrosis, gyrus atrophy or white matter demyelination” (Tam et al., 2012)

Difference of Opinions

AAP vs. PES

Timeline	0-4 hours	4-24hours	24-48 hours	>48 hours
AAP	<p>AAP: asymptomatic screened neonate- in first 4 hours, maintain blood glucose >40mg/dL prior to feeding. Between 4-24 hours, maintain blood glucose >45 mg/dL. If symptomatic- treat if blood glucose is <40mg/dL</p>			
PES	<p>PES (first 48 hours): Maintain blood glucose > 50mg/dL. Infants who are unable to maintain a blood glucose level >50 mg/dL in the first 48 hours of life may be at risk for a disorder causing persistent hypoglycemia.</p>			<p>PES (After 48 hours): A blood glucose >60mg/dL is recommended by the PES AFTER 48 hours of life. Infants at risk of having a persistent hypoglycemia syndrome are recommended by the PES to have a fast challenge of 6-8 hours with maintenance of blood glucose >70mg/dL.</p>

Signs, Symptoms, & Causes of Hypoglycemia



**Texas Children's
Hospital®**

Who to screen?

Neonates at risk for asymptomatic hypoglycemia

- Preterm
- Late preterm
- LGA
- SGA
- IUGR
- GDM/IDM
- Neonates requiring resuscitation at birth

Signs and Symptoms

- Fall into two categories
 - Neurogenic symptoms
 - Affect activity along the sympathetic nervous system
 - Are both adrenergic and cholinergic
 - Neuroglycopenic symptoms
 - Due to brain dysfunction from a deficient glucose supply
- Infant's may be asymptomatic or symptomatic
 - Symptomatic includes
 - CNS symptoms
 - Cardiopulmonary symptoms

Symptomatic Signs and Symptoms

Hypotonia

Lethargy, apathy

Tachypnea, apnea

Poor feeding

Jitteriness, seizures

Congestive heart failure

Cyanosis

Apnea

Hypothermia, temperature instability

Signs and Symptoms

- Autonomic nervous system
 - Adrenergic symptoms
 - Anxiety, tremulousness
 - Tachycardia
 - Palpitations
 - Cholinergic symptoms
 - Diaphoresis
 - Pallor
 - Hunger, nausea, and vomiting

Causes of Hypoglycemia

Limited glycogen stores

- Prematurity
- SGA
- IUGR

How does it work?

- Inadequate storage

- Who is at risk?
 - Preterm and Late preterm
 - SGA/IUGR
- What happened? Limited to no glucose storage
 - Premature birth prior to timing of glucose storage during end of 3rd trimester
 - Glucose utilization secondary to hostile uterine environment
- What does that mean?
 - Rapid depletion of limited storage of glucose

Causes of Hypoglycemia

Hyperinsulinemia or Persistent hyperinsulinemia hypoglycemia of infancy (PHHI)

- IDM
- Congenital Hyperinsulinemia
- Congenital Hypopituitarism

How does it work?

- Hyperinsulinemia

- Who is at risk?

- IDM/GDM

- LGA

- Congenital diabetes

- What happened? Increased fetal insulin production

- Elevated glucose levels cross placenta to which fetus responds by increasing insulin production

- Insulin levels remain high after delivery

- What does that mean?

- Hypoglycemia secondary to increased insulin production

- Neonate will readjust insulin level production over next several days after delivery

Causes of Hypoglycemia

- Increased glucose use
 - Hyperthermia
 - Polycythemia
 - Sepsis
 - Growth hormone deficiency
- Depleted glycogen stores
 - Stress
 - Prolonged resuscitation
 - Asphyxia
 - HIE

How does it work?

- Increased utilization

- Who is at risk?

- Hypoxia/Perinatal Asphyxia
 - Shock/Sepsis
 - Respiratory distress
 - Cardiac disease
 - Hypothermia

- What happened?

- Increased utilization of glucose secondary to increased metabolic rate

- What does that mean?

- Rapid depletion of adequate glucose stores

Causes of Hypoglycemia

- Decreased glycogenolysis, gluconeogenesis, or use of alternate fuels
 - Inborn errors of metabolism
 - Adrenal insufficiency

How does it work?

- Decreased glycogenolysis, gluconeogenesis, or use of alternate fuels
 - Who is at risk?
 - Chromosomal anomaly – inborn error of metabolism
 - Galactosemia
 - MSUD
 - PKU
 - What happened?
 - Inability to turn glucose into energy secondary to lacking specific protein enzymes
 - What does that mean?
 - Damage to liver, kidneys, brain, and eyes if not recognized

Treatment for hypoglycemia



**Texas Children's
Hospital®**

Treatment

- Identified infants at risk for hypoglycemia
 - Breast or bottle feed within 1st hour of life
 - Check glucose level 30 minutes after initial feeding
 - Continue to follow glucose levels for next 12 hours prior to feedings for IDM/LGA and next 24 hours for SGA/late preterm neonates

Rozance & Hay, 2016

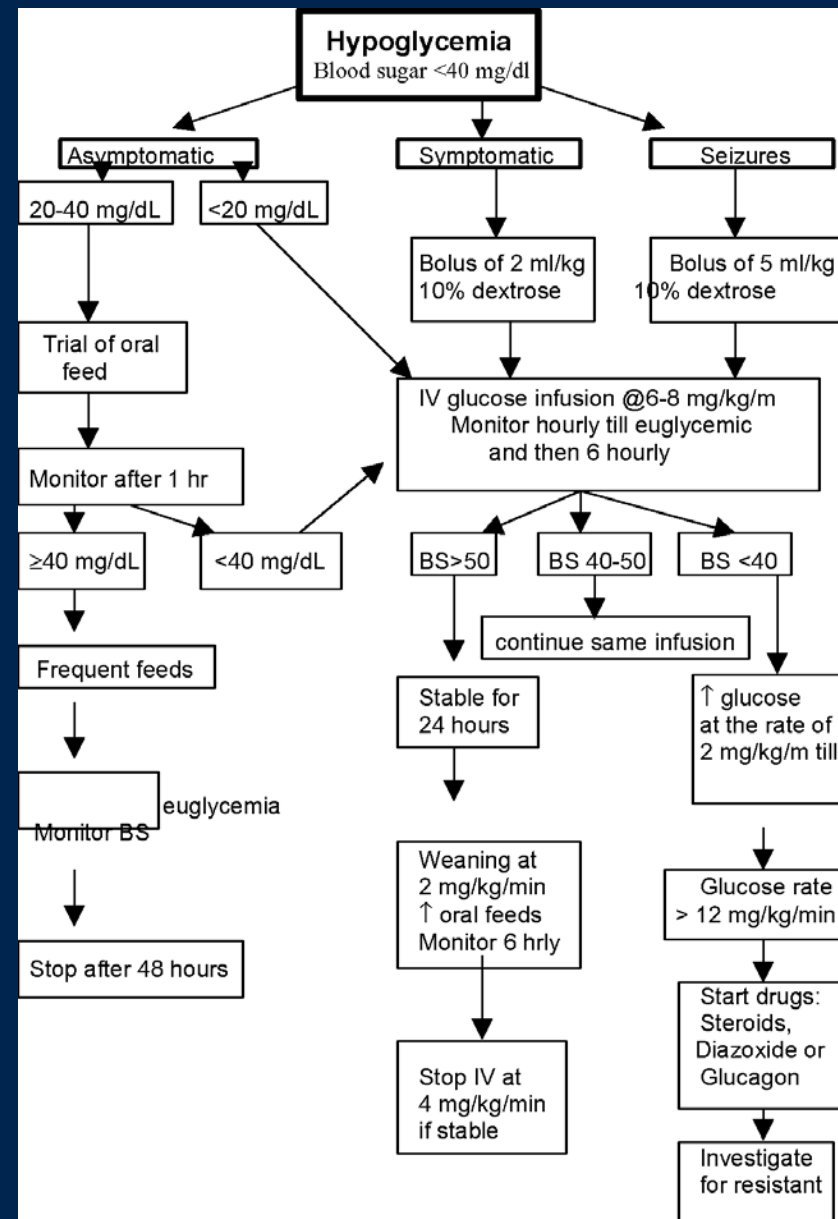
When to Treat

- Borderline hypoglycemia – asymptomatic
 - EBM or formula
 - Buccal glucose gel
- Moderate hypoglycemia (20 – 25 mg/dl)
 - IV glucose 2 ml/kg/dose

When to Treat

- Profound hypoglycemia (< 20 mg/dl)
 - IV glucose - D10w 2 ml/kg/dose
 - IV fluids – D10w at 80 ml/kg/day
- Symptomatic hypoglycemia
 - IV glucose - D10w 2 ml/kg/dose
 - IV fluids – D10w at 80 ml/kg/day

Hypoglycemic Algorithm



Treatment

- Asymptomatic

- Offer breastfeed or formula per parental preference
- Glucose Gel 40%
 - Dry cheek mucosa
 - Apply dose to mucosa and massage into cheek
 - Dose: 0.5 ml/kg/dose
 - For glucose levels >35 during 1st 48 hours of life
- Follow up glucose level after feed or per algorithm

Screening for and management of postnatal glucose homeostasis in late-preterm (LPT 34–36 6/7 weeks) and term small-for-gestational age (SGA) infants and infants who were born to mothers with diabetes (IDM)/large-for-gestational age (LGA) infants.

Screening and Management of Postnatal Glucose Homeostasis in Late Preterm and Term SGA, IDM/LGA Infants

[(LPT) Infants 34 – 36^{6/7} weeks and SGA (screen 0-24 hrs); IDM and LGA ≥34 weeks (screen 0-12 hrs)]

Symptomatic and <40 mg/dL → IV glucose

ASYMPTOMATIC

Birth to 4 hours of age

INITIAL FEED WITHIN 1 hour
Screen glucose 30 minutes after 1st feed

Initial screen <25 mg/dL

Feed and check in 1 hour

<25 mg/dL

↓
IV glucose*

25–40 mg/dL

↓
Refeed/IV glucose*
as needed

4 to 24 hours of age

Continue feeds q 2-3 hours
Screen glucose prior to each feed

Screen <35 mg/dL

Feed and check in 1 hour

<35 mg/dL

↓
IV glucose*

35 – 45 mg/dL

↓
Refeed/IV glucose*
as needed

Target glucose screen ≥45 mg/dL prior to routine feeds

* Glucose dose = 200 mg/kg (dextrose 10% at 2 mL/kg) and/or IV infusion at 5–8 mg/kg per min (80–100 mL/kg per d). Achieve plasma glucose level of 40-50 mg/dL.

Symptoms of hypoglycemia include: Irritability, tremors, jitteriness, exaggerated Moro reflex, high-pitched cry, seizures, lethargy, floppiness, cyanosis, apnea, poor feeding.

Committee on Fetus and Newborn Pediatrics
2011;127:575-579

PEDIATRICS®

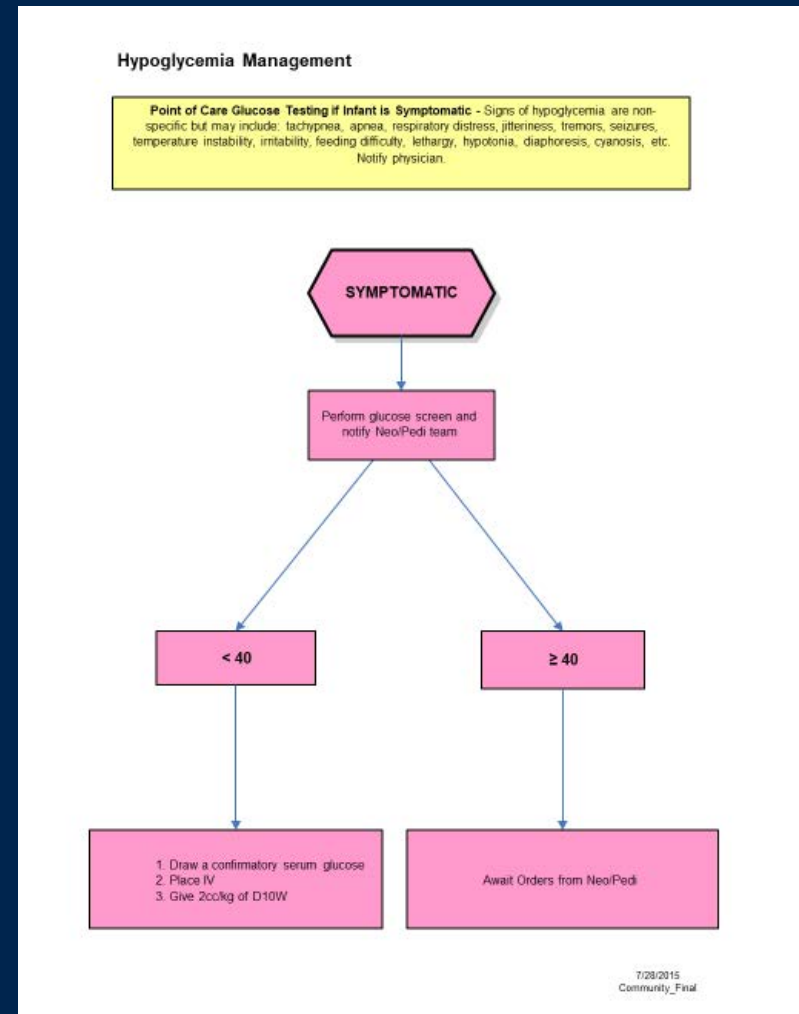
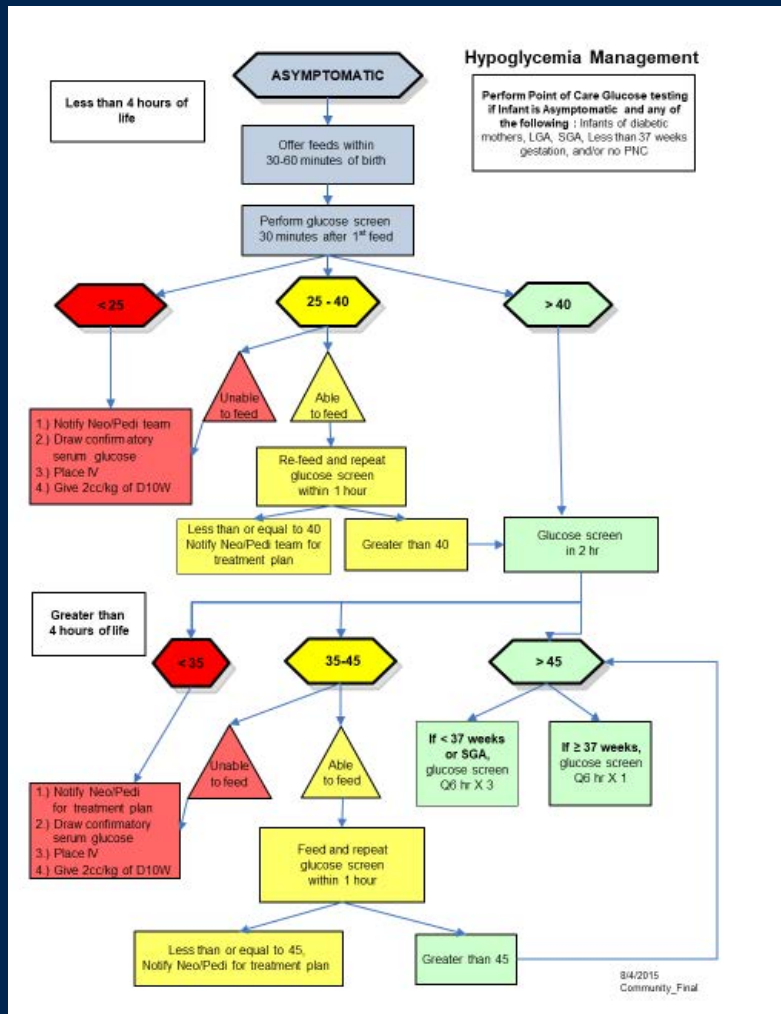
©2011 by American Academy of Pediatrics

Treatment

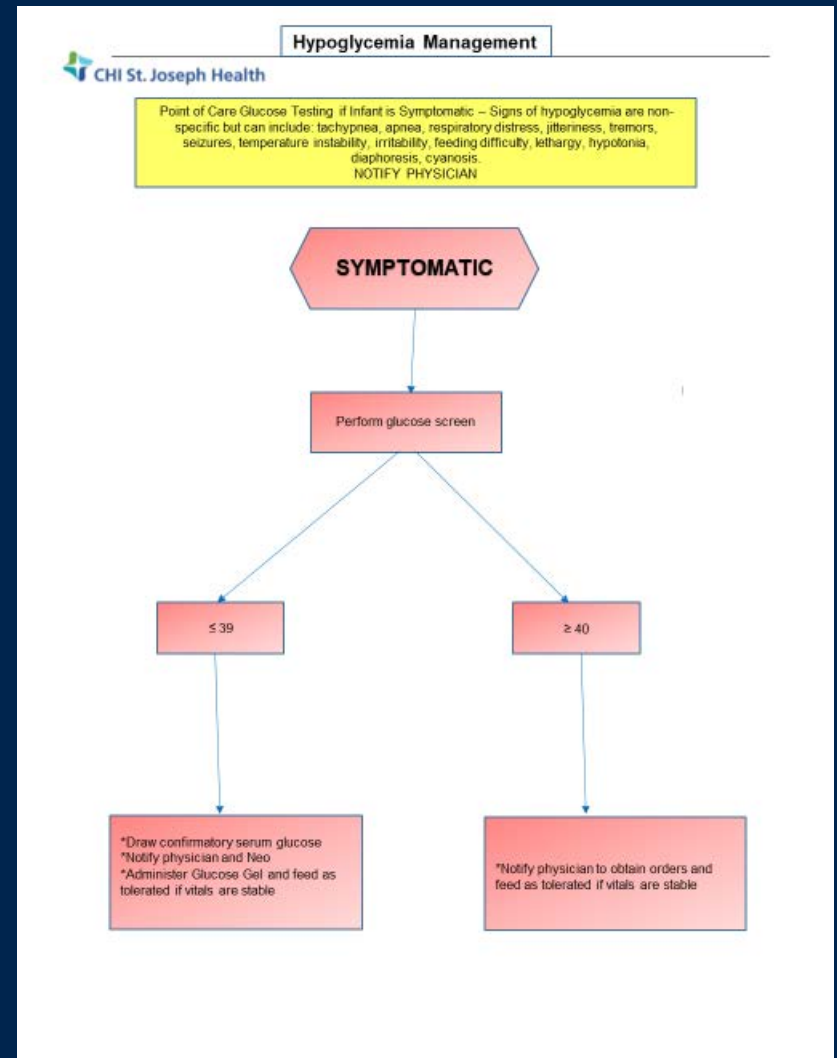
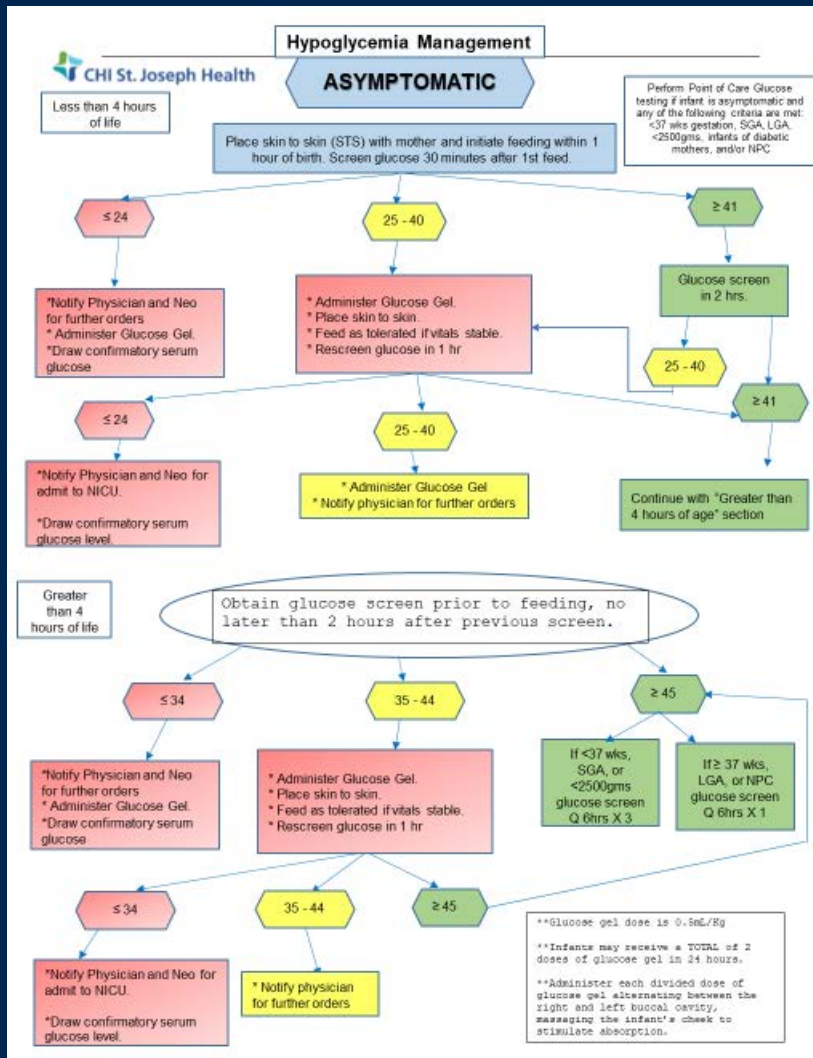
- Symptomatic

- D10w bolus – 2 ml/kg/dose
- IV maintenance fluids start at 80 ml/kg/day to give GIR 5.5 mg/kg/min
- Recheck glucose level 30 minutes after treatment given
 - Goal of 50 – 110 mg/dl x 2
- If low, repeat bolus and/or increase IV fluids
 - “Stair step” subsequent increase in treatments
 - D10 to 100 ml/kg/day
 - If need to increase change to D12.5 w
- If need to increase to D15 or higher, UCV or PICC line must be placed

TCH Hypoglycemia Algorithm



SJHRH Hypoglycemia Algorithm



Outcomes Short and Long Term



**Texas Children's
Hospital®**

Prognosis

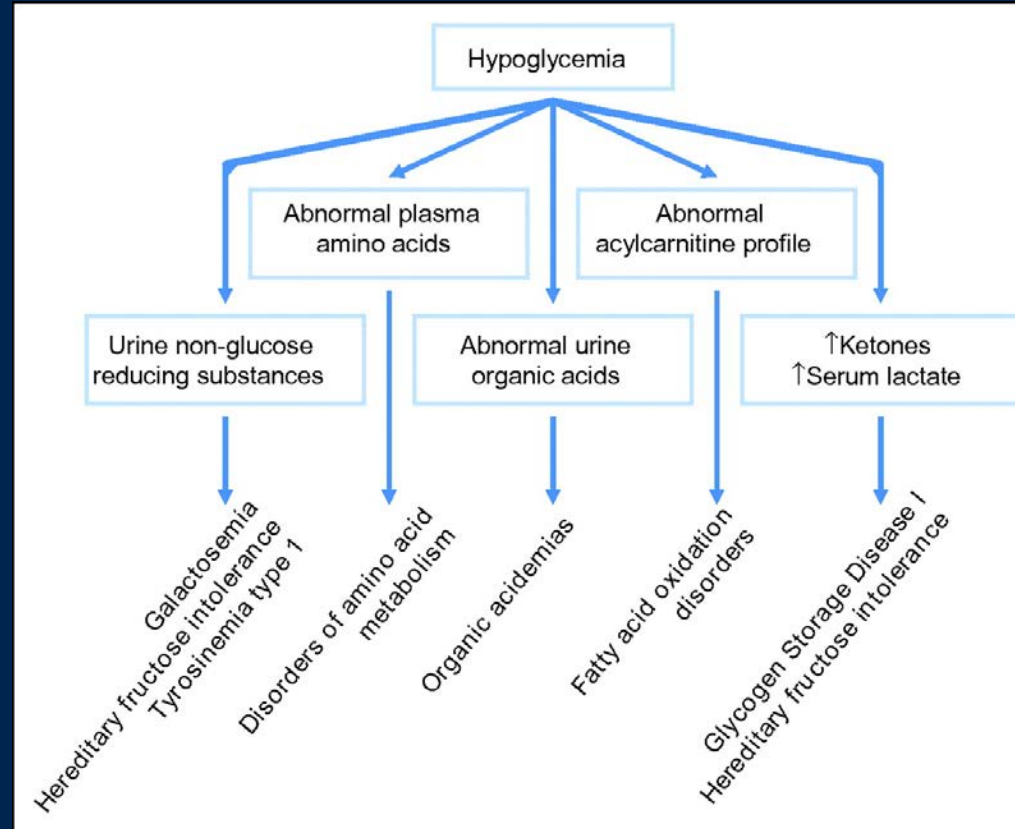
- It is not known at exactly what level or for how long hypoglycemia must occur in order to affect the neonate's developing brain.
 - However, risk of adverse neurologic damage increases with severity and duration of hypoglycemia
 - Infants are 2 – 3 times more likely to have issues with planning, memory, attention, problem-solving, and visual-motor coordination by 4 – 5 years of age
 - Raising glucose levels too fast, too high has an even greater risk of brain damage

Prognosis

- Major long-term sequelae include
 - Neurologic damage
 - Mental retardation
 - Recurrent seizure activity, epilepsy
 - Cerebral palsy
 - Developmental delay
 - Personality disorders
 - Cardiovascular impairment
 - Myocardial ischemia
 - Prolonged QT interval

Inborn Errors of Metabolism

Prognosis and long term outcomes are related to the timing of diagnosis and interventions to correct hypoglycemia



Brain Damage

- Irreversible brain damage with seizures noted with hypoglycemia of 20 mg/dl
 - Also known as Hypoglycemic Encephalopathy
- Seizures are located in the occipital and parietal lobes with similar patterns noted
 - Occipital lobe epilepsy
- Specific injury can be seen on MRI with injury to the posterior white matter and pulvinar edema

(Wong et al., 2013)

Conclusion

- Further research is needed

- To determine treatment of asymptomatic hypoglycemia
- Identify specific definitions for neonatal hypoglycemia
 - How low is too low

- Treatment

- Algorithm – further definition with consistent compliance in both NBN and NICU
- Avoid swings from too low to too high

Questions?



**Texas Children's
Hospital®**

References

- Adamkin, D. H. 2011. Postnatal glucose homeostasis in late-preterm and term infants. *Pediatrics*, 127, 575-579. DOI: 10.1542/peds.2010-3851. Retrieved on November 22, 2018 from http://pediatrics.aappublications.org/content/127/3/575?utm_source=TrendMD&utm_medium=TrendMD&utm_campaign=Pediatrics_TrendMD_0
- Adamkin, D. H. & Polin, R. A. 2016. Imperfect advice: Neonatal hypoglycemia. *Journal of Pediatrics*, 176(), 195-196. Retrieved on November 22, 2018 from [https://www.jpeds.com/article/S0022-3476\(16\)30259-1/pdf](https://www.jpeds.com/article/S0022-3476(16)30259-1/pdf)
- Campbell, H. 2017. Sick/not sick; low/not low. *Pediatrics in Review*. Retrieved on November 22, 2018 from <http://www.aappublications.org/news/aapnewsmag/2017/04/12/Sick-Not-Sick-Low-Not-Low-Pediatrics-In-Review-4-12-17.full.pdf>
- Chandran, S., Rajadurai, V., Alim, A., & Hussain, K. 2015. Current perspectives on neonatal hypoglycemia, its management, and cerebral injury risk. *Research and Reports in Neonatology*, 5, 17-30. Retrieved on December 10, 2018 from <https://www.dovepress.com/current-perspectives-on-neonatal-hypoglycemia-its-management-and-cereb-peer-reviewed-fulltext-article-RRN>
- Cornblath, M., et al. 2000. Controversies regarding definition of neonatal hypoglycemia; Suggested operational thresholds. *Pediatrics*, 105(5), 1141-1145. DOI: 10.1542/peds.105.5.1141. Retrieved on November 22, 2018 from https://www.researchgate.net/profile/Satish_Kalhan/publication/12525848_Controversies_Regarding_Definition_of_Neonatal_Hypoglycemia_Suggested_Operational_Thresholds/links/0046352e395529db68000000/Controversies-Regarding-Definition-of-Neonatal-Hypoglycemia-Suggested-Operational-Thresholds.pdf
- Cornblath, M.; Schwartz, R.; Aynsley-Green, A.; & Lloyd, J. K. 1990. Hypoglycemia in infancy: The need for a rational definition. *Pediatrics*, 85(5), 834-837. Retrieved on November 22, 2018 from <http://pediatrics.aappublications.org/content/85/5/834>
- Cranmer, H. 2018. Neonatal hypoglycemia. *Medscape*. Retrieved on November 25, 2018 from <https://emedicine.medscape.com/article/802334-overview#a4>
- Gandhi, K. 2017. Approach to hypoglycemia in infants and children. *Translational Pediatrics*, 6(4), 408-420. DOI: 10.21037/tp.2017.10.05
- Haelle, T. 2015. Neonatal hypoglycemia not tied to poor neurological outcomes. *Medscape*. Retrieved on November 22, 2018 from https://www.medscape.com/viewarticle/852781?src=trendmd_pilot
- Harris, D. L., Weston, P. J., Signal, M., Chase, J. G., & Harding, J. E. 2013. Dextrose gel for neonatal hypoglycemia (the sugar babies study): a randomized, double-blind, placebo-controlled trial. *Lancet* 2013; 382:2077-2083.
- Hawden, J. M. 2014. Neonatal hypoglycemia: Are evidence-based clinical guidelines achievable? *NeoReviews*, 15(3), e91-e98. DOI: 10.1542/neo.15-3-e91. Retrieved on November 22, 2018 from <http://neoreviews.aappublications.org/content/15/3/e91>
- Hawkes, C. P. & Stanley, C. A. 2017. Pathophysiology in neonatal hypoglycemia. *Fetal and Neonatal Physiology*. DOI: 10.1016/B978-0-323-35214-7.00153-0. Retrieved on November 22, 2018 from https://www.researchgate.net/publication/305843790_Pathophysiology_of_Neonatal_Hypoglycemia

References

- Karlson, K. 2013. The S.T.A.B.L.E. Program. 6th Edition.
- Kallem, V. K., Pandita, A., & Gupta, G. 2017. Hypoglycemia: When to treat? *Clinical Medicine Insight: Pediatrics*, 11, 1-9. DOI: 10.1177/1179556517748913. Retrieved on November 22, 2018 from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5734558/pdf/10.1177_1179556517748913.pdf
- Kelly, J. C. 2011. AAP sets guidelines for neonatal hypoglycemia. *Medscape*. Retrieved on November 22, 2018 from <https://www.medscape.com/viewarticle/738204>
- Lantzy, A. 2015. Neonatal hypoglycemia. Retrieved on November 22, 2018 from <https://www.merckmanuals.com/professional/pediatrics/metabolic.-electrolyte.-and-toxic-disorders-in-neonates/neonatal-hypoglycemia>
- Lee, K. G. 2017. Low blood sugar – newborns. *MedlinePlus*. Retrieved on November 22, 2018 from <https://medlineplus.gov/ency/article/007306.htm>
- Lubchenko, L. O. & Bard, H. 1971. Incidence of hypoglycemia in newborn infants classified by birth weight and gestational age. *Pediatrics*, 47(5), 831-838. Retrieved on November 22, 2018 from <http://pediatrics.aappublications.org/content/47/5/831>
- Lussy, R. C. 1999. A century of neonatal medicine. *Minnesota Medicine*, 82, 1-8. Retrieved on November 25, 2018 from <http://www.neonatology.org/classics/mmacentury.pdf>
- Ly, E., Alexander, J., Akinmboni, T., Woo, H., & Driscoll, C. 2016. Improving the diagnosis of neonatal hypoglycemia in a well-baby nursery. *BMJ Quality Improvement Reports*, 5(1), 1-4. DOI: 10.1136/bmjquality.u214381.w5806. Retrieved on November 22, 2018 from <https://bmjopenquality.bmj.com/content/5/1/u214381.w5806>
- McCoy, K. 2009. The history of diabetes. Retrieved on November 25, 2018 from <https://www.everydayhealth.com/diabetes/understanding/diabetes-mellitus-through-time.aspx>
- McGowan, J. E. 1999. Neonatal hypoglycemia. *Pediatrics in Review*, 20, e6-e15. DOI: 10.1542/pir.20-7-e6. Retrieved on November 22, 2018 from <http://pedsinreview.aappublications.org/content/pedsinreview/20/7/e6.full.pdf>
- Rozance, P. J. 2018. Pathogenesis, screening, and diagnosis of neonatal hypoglycemia. *UpToDate*. Retrieved on November 22, 2018 from <https://www.uptodate.com/contents/pathogenesis-screening-and-diagnosis-of-neonatal-hypoglycemia>
- Rozance, P. J. & Hays, W. W. 2012. Neonatal hypoglycemia – Answers, but more questions. *Journal of Pediatrics*, 161(5), 775-776. DOI: 10.1016/j.jpeds.2012.06.034. Retrieved on November 22, 2018 from [https://www.jpeds.com/article/S0022-3476\(12\)00675-0/fulltext](https://www.jpeds.com/article/S0022-3476(12)00675-0/fulltext)
- Rozance, P. J. & Hays, W. W. 2016. New approaches to management of neonatal hypoglycemia. *Maternal Health, Neonatology, and Perinatology*, 2(3), 1-7. DOI: 10.1186/s40748-016-0031-z. Retrieved on November 22, 2018 from <https://mhnjournal.biomedcentral.com/track/pdf/10.1186/s40748-016-0031-z>
- Ruboca, R. J. 2011. 'Clearer road map' Algorithm is key resource on screening, management of neonatal hypoglycemia in at-risk infants. *AAP News*, 32, 20. DOI: 10.1542/aapnews.2011323-20. Retrieved on November 25, 2018 from <http://www.aappublications.org/content/32/3/20>

References

- Sharma, A., Davis, A., & Shekhawat, P. S. 2017. Hypoglycemia in the preterm neonate: etiopathogenesis, diagnosis, management, and long-term outcomes. *Translational Pediatrics*, 6(4), 335-348. DOI: 10.21037/tp.2017.10.06. Retrieved on November 22, 2018 from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5682372/pdf/tp-06-04-335.pdf>
- Stanley, C. A.; et al. 2016. Imperfect advice: Neonatal hypoglycemia. *Journal of Pediatrics*, DOI: 10.1016/j.jpeds.2016.05.051
- Stokowski, L. A. & De León, D. D. 2015. Hypoglycemia in the newborn. *Medscape*. Retrieved on November 22, 2018 from https://www.medscape.com/viewarticle/854371?src=trendmd_pilot
- Straussman, S. & Levitsky, L. L. 2010. Neonatal hypoglycemia. *Endocrinology, Diabetes, & Obesity*, 17, 20-24. Retrieved on November 22, 2018 from <https://pdfs.semanticscholar.org/b163/ba349d7f922b2e88979c5c52dc37147aa3a8.pdf>
- Sweet, C. B., Grayson, S., & Polak, M. 2013. Management strategies for neonatal hypoglycemia. *Journal of Pediatric Pharmacology and Therapeutics*, 18(3), 199-208. DOI: 10.5863/1551-6776-18.3.199. Retrieved on November 22, 2018 from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3775554/pdf/j1551-6776-18-3-199.pdf>
- Su, J. & Wang, L. 2012. Research advances in neonatal hypoglycemic brain injury. *Translational Pediatrics*, 1(2), 108-115. DOI: [10.3978/j.issn.2224-4336.2012.04.06](https://doi.org/10.3978/j.issn.2224-4336.2012.04.06) Retrieved on December 10, 2018 from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4728881/>
- Tam, E. W. 2012. Hypoglycemia is associated with increased risk for brain injury and adverse neurodevelopmental outcomes in neonates at risk for encephalopathy. *Journal of Pediatrics*, 161(1), 88-93. DOI: [10.1016/j.jpeds.2011.12.047](https://doi.org/10.1016/j.jpeds.2011.12.047) Retrieved on December 10, 2018 from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3346850/>
- Thompson-Branch, A. & Havranek, T. 2017. Neonatal Hypoglycemia. *Pediatrics in Review*, 38(4), 147-155. Retrieved on November 22, 2018 from https://pedsinreview.aappublications.org/content/38/4_complete-issue.pdf
- Thornton, P. S.; et al. 2015. Recommendations from the Pediatric Endocrine Society for evaluation and management of persistent hypoglycemia in neonates, infants, and children. *Journal of Pediatrics*, 167(2), 238-245. Retrieved on November 22, 2018 from [https://www.jpeds.com/article/S0022-3476\(15\)00358-3/pdf](https://www.jpeds.com/article/S0022-3476(15)00358-3/pdf)
- Thornton, P. S. & Adamkin, D. 2016. Hypoglycemic guidelines: AAP versus PES. *Contemporary Pediatrics*. Retrieved on November 22, 2018 from <http://www.contemporarypediatrics.com/modern-medicine-feature-articles/hypoglycemia-guidelines-aap-vs-pes>
- UCSF Children's Hospital. 2004. Retrieved on November 22, 2018 from https://www.ucsfbenioffchildrens.org/pdf/manuals/52_Hypoglycemia.pdf
- Wright, N., Marinelli, K. A., & The Academy of Breastfeeding Medicine. 2014. ABM Clinical protocol #1: Guidelines for blood glucose monitoring and treatment of hypoglycemia in term and late-preterm neonates, Revised 2014. *Breastfeeding Medicine*, 9(4), 173-179. DOI: 10.1089/bfm.2014.9986. Retrieved on November 22, 2018 from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4026103/pdf/bfm.2014.9986.pdf>
- Wong, D. S. T. et al. 2013. Brain injury patterns in hypoglycemia in neonatal encephalopathy. *American Journal of Neuroradiology*, 34(7), 1456-1461. DOI: 10.3174/ajnr.3423. Retrieved on December 10, 2018 from <http://www.ajnr.org/content/34/7/1456>