Standards of admission capillary blood glucose levels in cesarean born neonates

Tatiana Smolkin, Irena Ulanovsky, Pnina Carasso, Imad R. Makhoul
Haifa, Israel

Background: **Neonatal hypoglycemia (NH) and cutoffs remain undefined. Our center screens all cesarean-delivered (CD) neonates for NH. We sought to define standards of admission capillary blood glucose levels (ACBGLs) in CD neonates who were at the lowest risk for hypoglycemia.**

Methods: **Of 4947 neonates, 519 met all 14 inclusion criteria. These highly-selected neonates were apparently the healthiest, least-stressed, earliest to be admitted to nursery and at lowest-risk for hypoglycemia. For each CD, cord blood gases and glucose were determined and each infant was screened for blood glucose at nursery admission.**

Results: **Sampling age was 41.6±15.3 minutes, a mean ACBGL of 52.3±10.7 mg/dL, and percentiles as follows: 1st percentile, 29.2; 3rd, 33.6; 5th, 35.0; 10th, 39.0; 25th, 46.0; 50th, 51.0; 75th, 58.0; 90th, 67.0; 95th, 71.0; 97th, 73.0, and 99th, 84.4. ACBGL rose significantly with increasing gestational age (P=0.004), increasing cord blood glucose (P<0.001), decreasing cord blood pH (P<0.001) and decreasing sampling age (P=0.027).**

Conclusions: **Setting uniform ACBGL cutoffs for NH definition is unachievable due to the enormous heterogeneity among newborns. Hence, we provide group-based ACBGL standards in CD neonates. We propose setting ACBGL cutoffs for use in CD neonates: 1) hypoglycemia: ACBGL <5th percentile (<35 mg/dL); and 2) interventional hypoglycemia: ACBGL <1st percentile (<30 mg/dL).**

World J Pediatr 2017;13(5):433-438

Key words: **capillary blood; cesarean delivery; glucose; hypoglycemia; newborn infant**

Author Affiliations: Department of Neonatology, Ruth Rappaport Children's Hospital, Haifa Israel, Rambam Health Care Campus, Haifa, Israel (Smolkin T, Ulanovsky I, Carasso P, Makhoul IR); The Ruth & Bruce Rappaport Faculty of Medicine, Technion-Israel Institute of Technology, Haifa, Israel (Smolkin T, Ulanovsky I, Makhoul IR)

Corresponding Author: Imad R. Makhoul, MD, PhD, Department of Neonatology, Rambam Health Care Campus, Bat-Galim, Haifa 31096, Israel (Tel: 972-4-7774116; Fax: 972-4-7774126; Email: makhoul@rambam.health.gov.il)

doi: 10.1007/s12519-017-0016-7
Online First February 2017

Introduction

The definition of neonatal hypoglycemia (NH) remains controversial due to paucity of high-quality studies and absence of significant correlations between plasma glucose concentration, clinical signs, and long-term outcomes.[1-3] Differing management protocols have made it difficult to set evidence-based clinical guidelines and intervention cutoffs.[4-6] In 2011, the American Academy of Pediatrics (AAP)[7] criticized the use of Lucas et al definition of NH (blood glucose <47 mg/dL).[5] To date, no specific value or range of blood glucose is known to be predictive of hypoglycemia symptoms.[1,2,8-10] The blood glucose may reach the nadir of 30 mg/dL or less within 1 to 2 hours after birth.[6,7,11,12] This transient hypoglycemia is self-limited, asymptomatic, and reflects adaptation to extra-uterine life.[13-17] In appropriate for gestational age (AGA) term neonates, the mean pooled blood glucose levels were 54 mg/dL and 63 mg/dL at one and two hours of age, respectively.[13-16,18,19] In addition, the World Health Organization[20] summarized the disputed definitions of neonatal hypoglycemia and set the threshold of hypoglycemic as 30 mg/dL in term AGA infants.

Screening indications for NH after birth remain disputed, except for the four at-risk groups defined by the AAP in 2011: small for gestational age, late preterm infant, full-term large for gestational age, and infant of diabetic mother.[7] To date, no published data exist on central nervous system injury due to brief asymptomatic hypoglycemia.[7,8] However, persistent asymptomatic hypoglycemia may cause neurological impairment.[5] Adamkin[21] summarized the three remaining unanswered questions regarding NH: what is meant by too low? how low is too low? what glucose level results in irreversible changes in brain function and structure? In light of the above, we sought to determine the cesarean-delivered (CD) infants' specific admission capillary blood glucose

level (ACBGL) standards and percentiles in healthy neonates who were at the lowest-risk for hypoglycemia. This updated information on NH might help policy makers when trying to settle the hypoglycemia-definition controversy.

Methods

Study design

This retrospective observational study was performed in the newborn nursery of the Rambam Health Care Campus in Haifa, Israel. The study was approved by the Institutional Helsinki Committee, which waived the requirement to obtain written consent from the parents of studied infants.

Study population

All 4947 neonates admitted to the nursery between March 1, 2014 and February 28, 2015 were assessed for study participation. To qualify for inclusion in the study group, a neonate had to meet the following 14 criteria: healthy, without endocrinologic problems or abnormal findings on physical examination; a singleton, born at term, between 37 and 42 weeks' gestation; AGA (between the 3rd and 97th percentiles of the Israeli growth curve);[22] born via elective CD with spinal anesthesia; cord-blood pH≥7.15; 5-minute Apgar score ≥7; no transient tachypnea of newborn; no prior feeding; no maternal insulin-dependent diabetes mellitus; no maternal gestational diabetes mellitus; and no maternal treatment with serotonin selective reuptake inhibitors or beta-blockers. Neonates not fulfilling all the above criteria were excluded from the study. Fig. 1 shows the algorithm for the selection of study participants, yielding a study population of 519 highly-selected neonates at the lowest risk for hypoglycemia. Being born by elective CD, these neonates were the earliest to be admitted and checked for blood glucose in the nursery. Perinatal and neonatal variables of neonates and their mothers were extracted from the patient database of the Rambam Health Care Campus.

Neonatal hypoglycemia screening

According to our standard procedure, at risk neonates, as set by the AAP, are routinely screened for hypoglycemia.[7] Furthermore, we also routinely screen for hypoglycemia all CD neonates. For each CD neonate, a sample of mixed venous cord blood was obtained for determination of blood gases and glucose and each infant was screened for blood glucose at nursery admission.

Measurement of blood glucose concentrations

The umbilical cord blood glucose was measured using a blood gas analyzer (Omni 6, AVL, Roche Diagnostics, Texas, USA). The blood glucose for capillary blood was obtained using a warmed heel stick and measured with a glucometer (Stat Strip, Glue KET, Nova Biomedical Corporation, UK, and Waltham, MA, USA). For the purpose of this study, only the first measured ACBGLs, sampled prior to feeding or intervention, and were analyzed. Whenever the ACBGL was less than 35 mg/dL, it was immediately repeated using a different glucometer and a strip from another strip-box. If the difference was less than 5 mg/dL, we averaged the two results. However, if the difference was greater than 5 mg/dL we conducted a third test and used the average of the two closest results.

Statistical analysis

Statistical analysis was performed using SPSS (Statistics Products Solutions Services) 21.0 software for Windows (IBM Corp. Armonk, NY, USA). The Mann-Whitney test was used to evaluate for a significant association between blood glucose and infants gender. Analysis of variance (ANOVA) and Bonferroni tests for multiple comparisons were used for detection of significant association between blood glucose and relevant perinatal and neonatal variables. A *P* value of less than 0.05 was considered statistically significant.

Results

The perinatal and neonatal characteristics and ACBGL

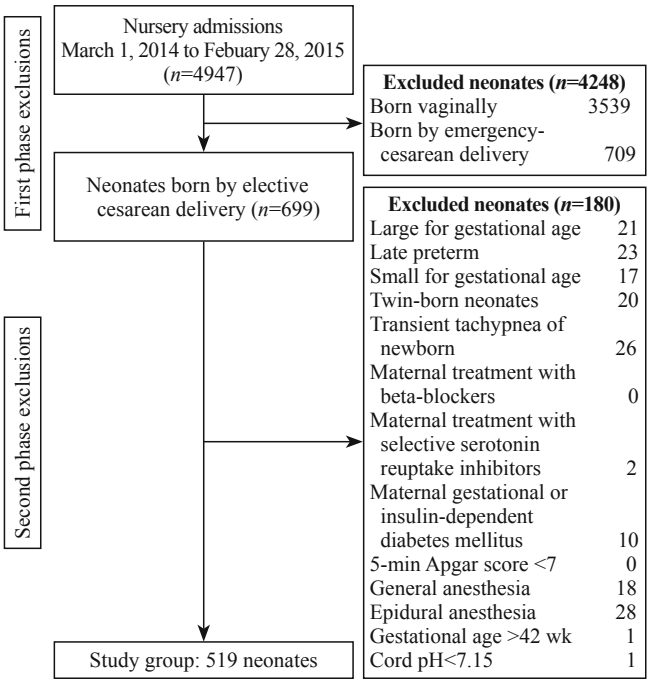

Fig. 1. Algorithm showing the flow of participants through the selection process of the study group.

percentiles of the 519 neonates are shown in Table 1. Noteworthy, is that the 1st, 5th and 25th percentiles are 29.2 mg/dL, 35 mg/dL and 46 mg/dL, respectively. The mean sampling age of ACBGL was 41.6±15.3 minutes. The distribution of ACBGLs obtained within 120 minutes after birth from the 519 studied neonates is displayed in Fig. 2 and shows a linear relationship with sampling age: R^2 Linear=0.010, y=55.17±0.07x.

Table 2 shows correlations between ACBGL and perinatal variables. ACBGL rose significantly with increasing gestational age (P=0.004), increasing cord blood glucose concentration (P<0.001), decreasing cord blood pH (P<0.001) and decreasing sampling age (P=0.027). ACBGL was not affected by birth weight,

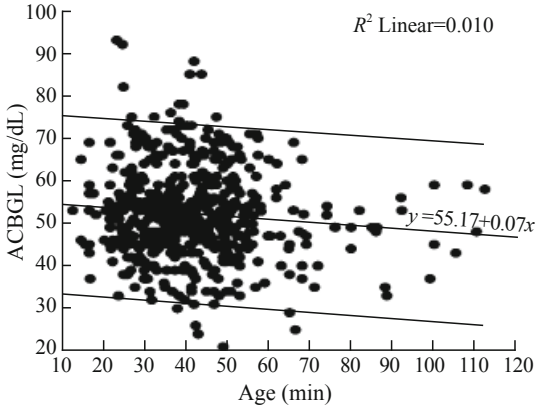

Fig. 2. Distribution of admission capillary blood glucose levels (ACBGL) obtained within 120 minutes after birth from the 519 studied neonates: R^2 Linear=0.010, y=55.17±0.07x.

Table 1. Perinatal and neonatal characteristics of the 519 studied neonates (all asymptomatic)

Variables	n	Mean±standard deviation (median, range)
Gender: male/female	519	267/252
Gestational age (wk)	519	38.6±0.9 (38.5, 37-42)
Birth weight (g)	519	3265±363 (3245, 2245-3970)
1-min Apgar score	519	9±0.4 (9, 6-10)
5-min Apgar score	519	10±0.2 (10, 7-10)
Age on admission (min)	519	31.9±11.6 (31, 9-81)
Admission body temperature (˚C)	519	36.5±0.4 (36.5, 35.2-37.4)
Blood glucose sampling age (min)	519	41.6±15.3 (40.2, 12.6-111.8)
Blood glucose (neonate) (mg/dL)	519	52.3±10.7 (51, 21-93)
pH (umbilical cord blood)	497	7.3±0.1 (7.3, 7.15-7.4)
Glucose level (umbilical cord blood) (mg/dL)	484	61.1±11.1 (61, 34-104)
Blood glucose percentiles (mg/dL)	519	

1st	3rd	5th	10th	25th	50th	75th	90th	95th	97th	99th
29.2	33.6	35.0	39.0	46.0	51.0	58.0	67.0	71.0	73.0	84.4

Table 2. Correlation between admission blood glucose level* (mg/dL) and perinatal variables

Variables	n	Mean±standard deviation (median, range)	P value
Blood glucose (mg/dL) by gender			
Female	252	51.5±11.2 (51.0, 24-93)	0.060 (Mann-Whitney test)
Male	267	53.1±10.1 (52, 21-88)	
Blood glucose by gestational age (wk)			
≤37.6	58	51.6±10.9 (50.5, 33-85)	0.004 (ANOVA)
38-38.6	291	51.1±10.3 (50, 21-93)	0.003 (39-42 *vs*. 38-38.6)
39-42	170	54.5±10.9 (53, 26-92)	
Blood glucose by sampling age (min)			
15-29	115	53.3±11.0 (51, 33-93)	0.027 (ANOVA)
30-44	221	52.8±11.0 (52, 24-88)	0.024 (≥60 *vs*. <30)
45-59	138	52.1±10.0 (51, 21-75)	0.028 (≥60 *vs*. 30-44)
≥60	45	47.9±9.4 (48, 25-69)	
Blood glucose by body temperature (˚C)			
35.2-35.5	11	56.3±12.3 (50, 44-82)	0.126 (ANOVA)
35.6-36.0	52	52.4±12.2 (51, 24-92)	
36.1-36.5	221	51.3±9.7 (51, 21-78)	
36.6-37.0	203	53.5±11.1 (52, 31-93)	
37.1-37.5	32	50.3±10.6 (47.5, 34-71)	
Blood glucose by cord blood pH			
7.15-7.23	89	56.0±12.4 (54, 21-93)	<0.001 (ANOVA)
7.24-7.32	313	51.9±10.1 (51, 24-82)	0.003 (7.15-7.23 *vs*. 7.24-2.32)
7.33-7.40	95	49.7±8.6 (49, 30-74)	<0.001 (7.15-7.23 *vs*. 7.33-7.40)
Blood glucose by cord blood glucose (mg/dL)			
<50	87	47.4±9.6 (47, 25-78)	<0.001 (ANOVA)
50-71	323	52.3±9.5 (51, 21-78)	
≥72	74	56.9±11.5 (57, 30-85)	

*: obtained within 120 minutes after birth without prior feeding. ANOVA: analysis of variance.

Apgar score, admission age and body temperature.

The ACBGL decreased significantly with a nadir around 1-1.5 hours of age.[7] The blood glucose ranged from 21 to 93 mg/dL. Moreover, twenty-six (5%) infants had ACBGL of less than 35 mg/dL, albeit all asymptomatic. Five (1%) neonates had a blood glucose <30 mg/dL, all of whom were asymptomatic.

Discussion

To date, trials for defining NH have been frustrating and unrewarding. The majority of healthy asymptomatic newborns with low blood glucose levels after birth normalize within hours.[7,11,23] Lucas et al[5] suggested a blood glucose cutoff of 47 mg/dL,[6,7,23,24] a value that offered the greatest predictor for poor developmental scores. Nevertheless, Hay et al[25] critically appraised the evidence regarding this NH definition,[5] concluding that it was without rigorous scientific justification.[1,2,7,9,25,26] In 2000, a consensus[2,24] was compiled suggesting the following intervention cutoffs: any blood glucose level <18 mg/dL; abnormal clinical signs; risk for impaired metabolic adaptation.[2] In 2009, a workshop concluded the following:[25] 1) no evidence-based study exists as to plasma glucose concentration or range to define pathologic hypoglycemia; 2) monitoring, prevention and treatment of NH remains largely empirical.

In 2011, the AAP recommended a transition from Lucas et al definition (47 mg/dL)[5] to threshold values of 25-30 mg/dL.[7] This change was based on the following: 1) all symptomatic infants had blood glucose <20-25 mg/dL after birth; 2) equally low blood glucose values occurred during recurrent or persistent hypoglycemia syndromes; 3) no solid evidence exists as to neurologic damage caused in infants with asymptomatic hypoglycemia;[27] and 4) treating transient hypoglycemia does not improve short-term and long-term outcomes.[10,16]

According to Adamkin,[21] the definition of clinically significant NH remains among the most confused and contentious issues in neonatology. We think that failure to set definition for NH has been partially due to the significant heterogeneity among newborns, mainly their inherent risk for NH, their differing perinatal characteristics and the significantly higher blood glucose values of vaginally-born term-AGA neonates as compared to CD mates.[22,28-30] Hence, we think that setting uniform ACBGL cutoffs for NH definition and intervention is unachievable. Future research should rather focus on setting separate ACBGL standards and cutoffs for each subgroup of neonates. These subgroups include: 1) vaginally-born term AGA healthy neonates; 2) AAP at-risk groups for NH (small for gestational age, large for gestational age, late preterm, infants of diabetic mothers); 3) cesarean delivered neonates; and, 4) term sick neonates or those born by vacuum extraction. Our highly selected CD group is an appropriate example for our proposed approach: these CD neonates were supposedly the healthiest, the least stressed and at the lowest risk for hypoglycemia, and thus can serve as a reference for normal ACBGLs prior to feeding in CD neonates.[7,12,22,30-32]

Adamkin[21] mentioned five "competing" approaches for defining NH: 1) epidemiologic: defines blood glucose in healthy infants, using empirically derived cut-off blood glucose values;[2,25,27] 2) clinical: focuses on blood glucose levels during symptomatic NH; 3) neurophysiologic: includes measurement of neurophysiologic changes in relation to blood glucose levels; 4) metabolic/endocrinologic: analyzes data on transitional NH where hyperinsulinism is reflected by low glucose concentrations in the first 48 hours;[33-36] and 5) neurodevelopmental: used to define significant NH and produce algorithms for screening and management.[5,37]

Our study conforms to Adamkin's epidemiological approach for defining NH.[21] We empirically suggest using our 5th percentile ACBGL (35 mg/dL) for defining NH in CD neonates, based on the following: 25% of our low-risk neonates would have been considered hypoglycemic should we have adopted the Lucas et al[5] definition; choice of the 10th percentile (39 mg/dL) is inappropriate because it is higher than the discussed AAP threshold values of 32-35 mg/dL; ACBGLs less than 30 mg/dL (<1st percentile) are considered too low for defining NH but might be appropriate as an intervention cutoff.[7,11] Our proposed ACBGL of 35 mg/dL (5th percentile) or 33.6 mg/dL (3rd percentile) are within the suggested cutoff values by the Canadian Pediatric Society[11] and the AAP[7] in the last decade.

The present study shows that within the first two hours after birth, the ACBGL decreased significantly with a nadir around 1-1.5 hours of age.[7] Our study neonates supposedly had the lowest risk for hypoglycemia, even though their blood glucose ranged from 21 to 93 mg/dL. Moreover, twenty-six infants with an ACBGL of less than 35 mg/dL and five with a blood glucose <30 mg/dL were all asymptomatic. This may represent a physiologic nadir for blood glucose after birth. These neonates would have been overlooked if not screened for hypoglycemia.

The bedside reagent test-strip glucose analyzers' results are quick but vary up to 10-20 mg/dL.[25,36] resulting in slow availability of results and a potential delay in initiation of treatment.[7] The availability of bedside point of care that provides timely and quick results of ACBGL obtained via a heel-stick glucometer outweighs its disadvantages. Nomograms of plasma glucose concentration are currently the gold standard

for defining normal blood glucose concentration. Nonetheless, most centers worldwide use bedside glucometers and provide treatment according to their results. Hence, it may now be the time to set standards for capillary blood glucose concentration in neonates.

The limitations of the present study include 1) its retrospective characteristic; 2) lack of prolonged neurodevelopmental follow-up; 3) different blood sources and methods for measuring glucose level in whole capillary blood and whole umbilical cord blood and 4) our study group is not the ideal representative group, because the CD rate in our institution is 25%-30%. Comparison of our CD neonates with those born vaginally is worth investigation in the future; and 5) lack of validation of heal-stick blood glucose levels by plasma glucose measurement.

Unfortunately, the blood glucose percentiles were measured only by capillary blood. Advances in glucose meter technology have resulted in significant improvement of accuracy and precision of meters. But, a variety of factors can affect glucose meter results, including operator technique, environmental exposure and patient factors. Then, there are some problems with the interpretation of the findings. There are physical differences between the glucose concentration in serum/plasma and whole blood as well as venous compared to capillary blood. Targets should be individualized in each institution and in each setting based on the methodology of glucose testing and the needs of a given patient population to reflect, at a minimum, the 1.11 whole blood-to-plasma glucose conversion factor recommended by the International Federation of Clinical Chemistry.[38]

In conclusion, implementing the Adamkin[21] epidemiologic approach, we propose the following cutoffs for use in CD neonates: 1) hypoglycemia: ACBGL <5th percentile (<35 mg/dL); and 2) interventional hypoglycemia: ACBGL<1st percentile (<30 mg/dL). Our updated ACBGL standards in CD neonates might help policy makers when discussing definition of NH.

Acknowledgements

The authors thank the Nursing and Medical Staff of the Nursery, Mrs. Tatyana Mashiach, for statistical analysis of data, and Larisa Halif, Computer Department, Rambam Health Care Campus, Haifa, Israel.

Funding: None.
Ethical approval: The study was approved by the Institutional Helsinki Committee, which waived the requirement to obtain written consent from the parents of studied infants.
Competing interest: None declared.
Contributors: Smolkin T wrote the main body of the article under the supervision of Makhoul IR. Ulanovsky I and Carasso P provided advice on medical aspects.

References

1 Sinclair JC. Approaches to definition of neonatal hypoglycemia. Acta Paediatr Jpn 1997;39 Suppl 1:S17-S20.
2 Cornblath M, Hawdon JM, Williams AF, Aynsley-Green A, Ward-Platt MP, Schwartz R, et al. Controversies regarding definition of neonatal hypoglycemia: suggested operational thresholds. Pediatrics 2000;105:1141-1145.
3 Kalhan S, Peter-Wohl S. Hypoglycemia: what is it for the neonate? Am J Perinatol 2000;17:11-18.
4 Hawdon JM. Neonatal hypoglycemia: are evidence-based clinical guidelines achievable? Neoreviews 2014;15:e91-e98.
5 Lucas A, Morley R, Cole TJ. Adverse neurodevelopmental outcome of moderate neonatal hypoglycaemia. BMJ 1988;297:1304-1308.
6 Harris DL, Weston PJ, Battin MR, Harding JE. A survey of the management of neonatal hypoglycaemia within the Australian and New Zealand Neonatal Network. J Paediatr Child Health 2014;50:E55-E62.
7 Committee on Fetus and Newborn, Adamkin DH. Postnatal glucose homeostasis in late-preterm and term infants. Pediatrics 2011;127:575-579.
8 Rozance PJ, Hay W. Hypoglycemia in newborn infants: features associated with adverse outcomes. Biol Neonate 2006;90:74-86.
9 Sinclair JC, Steer PA. Neonatal hypoglycemia and subsequent neurodevelopment: a critique of follow-up studies. CIBA Foundation discussion meeting: hypoglycemia in infancy; 1989 October 17; London, England.
10 Boluyt N, van Kempen A, Offrin M. Neurodevelopment after neonatal hypoglycemia: a systematic review and design of an optimal future study. Pediatrics 2006;117:2231-2243.
11 Croke J, Sullivan M, Ryan-Drover A, Randell E, Andrews W, Aziz K. Two hour BGLs in at-risk babies: an audit of Canadian guidelines. Paediatr Child Health 2009;14:238-244.
12 Kayıran SM, Gürakan B. Screening of blood glucose levels in healthy neonates. Singapore Med J 2010;51:853-855.
13 Srinivasan G, Pildes RS, Cattamanchi G, Voora S, Lilien LD. Plasma glucose values in normal neonates: a new look. J Pediatr 1986;109:114-117.
14 Heck LJ, Erenberg A. Serum glucose levels in term neonates during the first 48 hours of life. J Pediatr 1987;110:119-122.
15 Hoseth E, Joergensen A, Ebbesen F, Moeller M. BGLs in a population of healthy, breast fed, term infants of appropriate size for gestational age. Arch Dis Child Fetal Neonatal Ed 2000;83:F117-F119.
16 Dollberg S, Bauer R, Lubetzky, Mimouni FB. A reappraisal of neonatal blood chemistry reference ranges using the Nova M electrodes. Am J Perinatol 2001;18:433-440.
17 Wight N, Marinelli KA, Academy of Breastfeeding Medicine. ABM clinical protocol #1: guidelines for blood glucose monitoring and treatment of hypoglycemia in term and late-preterm neonates, revised 2014. Breastfeed Med 2014;9:173-179.
18 Sweet DG, Hadden D, Halliday HL. The effect of early feeding on the neonatal BGL at 1-hour of age. Early Hum Dev 1999;55:63-66.

19 Diwakar KK, Sasidhar MV. Plasma glucose levels in term infants who are appropriate size for gestation and exclusively breast fed. Arch Dis Child Fetal Neonatal Ed 2002;87:F46-F48.
20 Koh D, Hume R, Eisenhofer G, Ogston S, Watson J, Williams F. Maternal and fetal factors which influence cord blood glucose levels in term infants delivered by cesarean section. J Perinat Med 2015;43:339-346.
21 Adamkin DH. Metabolic screening and postnatal glucose homeostasis in the newborn. Pediatr Clin North Am 2015;62:385-409.
22 Dollberg S, Haklai Z, Mimouni FB, Gorfein I, Gordon ES. Birth weight standards in the live-born population in Israel. Isr Med Assoc J 2005;7:311-314.
23 Hawdon JM. Definition of neonatal hypoglycaemia: time for a rethink? Arch Dis Child Fetal Neonatal Ed 2013;98:F382-F383.
24 Tin W. Defining neonatal hypoglycaemia: a continuing debate. Semin Fetal Neonatal Med 2014;19:27-32.
25 Hay WW Jr, Raju TN, Higgins RD, Kalhan SC, Devaskar SU. Knowledge and research needs for understanding and treating neonatal hypoglycemia: workshop report from Eunice Kennedy Shriver National Institute of Child Health and Human Development. J Pediatr 2009;155:612-617.
26 McGowan JE. Neonatal hypoglycemia: fifty years later, the questions remain the same. Neoreviews 2004;5:e363-e364.
27 Cornblath M, Ichord R. Hypoglycemia in the neonate. Semin Perinatol 2000;24:136-149.
28 Cole MD, Peevy K. Hypoglycemia in normal neonates appropriate for gestational age. J Perinatol 1994;14:118-120.
29 Hussein SM, Salih Y, Rayis DA, Bilal JA, Adam I. Low neonatal BGLs in cesarean-delivered term newborns at Khartoum Hospital, Sudan. Diagn Pathol 2014;9:112.
30 Altimier LB, Roberts W. One Touch II hospital system for neonates: correlation with serum glucose values. Neonatal Netw 1996;15:15-18.
31 Cissoko H, Jonville-Béra AP, Swortfiguer D, Giraudeau B, Autret-Leca E. Neonatal after exposure to beta adrenergic blockers late in pregnancy. Arch Pediatr 2005;12:543-547.
32 Källén B, Reis M. Neonatal complications after maternal concomitant use of SSRI and other central nervous system active drugs during the second or third trimester of pregnancy. J Clin Psychopharmacol 2012;32:608-614.
33 Stanley CA, Baker L. Hyperinsulinism in infants and children: diagnosis and therapy. Adv Pediatr 1976;23:315-355.
34 Glaser B, Kesavan P, Heyman M, Davis E, Cuesta A, Buchs A, et al. Familial hyperinsulinism caused by an activating glucokinase mutation. N Engl J Med 1998;338:226-230.
35 Hoe FM, Thornton PS, Wanner LA, Steinkrauss L, Simmons RA, Stanley CA. Clinical features and insulin hyperinsulinism. J Pediatr 2006;148:207-212.
36 Stanley CA, Rozance PJ, Thornton PS, De Leon DD, Harris D, Haymond MW, et al. Re-evaluating "transitional neonatal hypoglycemia": mechanism and implications for management. J Pediatr 2015:166:1520-1525.e1.
37 Adamkin DH. Glucose metabolism. In: Polin RA, Yoder MC, eds. Workbook in practical neonatology. Philadelphia: Elsevier, 2014: 63.
38 Tonyushkina K, Nichols JH. Glucose meters: a review of technical challenges to obtaining accurate results. J Diabetes Sci Technol 2009;3:971-980.

Received February 29, 2016
Accepted after revision June 17, 2016