A Quality-Improvement Initiative to Reduce NICU Transfers for Neonates at Risk for Hypoglycemia

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BACKGROUND AND OBJECTIVE: Neonatal hypoglycemia is a common problem, often requiring management in the NICU. Nonpharmacologic interventions, including early breastfeeding and skin-to-skin care (SSC), may prevent hypoglycemia and the need to escalate care. Our objective was to maintain mother-infant dyads in the mother-infant unit by decreasing hypoglycemia resulting in NICU transfer.

METHODS: Inborn infants ≥35 weeks' gestation with at least 1 risk factor for hypoglycemia were included. Using quality-improvement methodology, a bundle for at-risk infants was implemented, which included a protocol change focusing on early SSC, early feeding, and obtaining a blood glucose measurement in asymptomatic infants at 90 minutes. The primary outcome was the overall transfer rate of at-risk infants to the NICU. Secondary outcomes were related to protocol adherence. Balancing measures, including the rate of symptomatic hypoglycemia and sepsis evaluations, were monitored. Statistical process control charts using standard interpretation rules were used to monitor for improvement in key aims.

RESULTS: For infants at risk for hypoglycemia, the NICU transfer rate decreased from 17% to 3% overall. Documented early feeding and SSC in at-risk newborns increased. The percent of at-risk infants transferred to the NICU who did not require intravenous dextrose decreased from 5% at baseline to 0.7% after intervention. There were no adverse outcomes observed in the period before or after the intervention.

CONCLUSIONS: The implementation of a quality-improvement intervention promoting SSC and early feeding in at-risk infants was associated with a decreased rate of transfer to the NICU for hypoglycemia.

Neonatal hypoglycemia is a common problem estimated to affect 15% to 30% of newborns.[1,2] Of infants with hypoglycemia, ~10% require intensive care management, with an estimated cost of $2.1 billion annually in the United States.[3–6] Infants known to be at risk for neonatal hypoglycemia include those born with 1 or more of the following risk factors: late preterm (LPT) gestation (34 0/7–36 6/7 weeks), small for gestational age (SGA), large for gestational age (LGA), and being an infant of a mother with diabetes (IDM).[5,7–10] Given the high rate of preterm birth and the rising incidence of maternal diabetes, the population of infants at risk for hypoglycemia is likely to grow.[11]

There is a lack of consensus on the definition of hypoglycemia in newborns, whether there are risks associated with transient

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Ms LeBlanc was the primary investigator, conceptualized and designed the project, collected and analyzed data, and drafted the initial manuscript; Ms Haushalter created the protocol used in the project, performed data collection, and assisted with the manuscript drafting and revision; Drs Seashore and Wood assisted in the design of the project, provided input during implementation, and reviewed and revised the manuscript; Dr Steiner provided feedback during the project implementation, assisted with data analysis, and reviewed and revised the manuscript; Dr Sutton assisted in the design of the project, performed data collection and analysis, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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hypoglycemia, and the ideal threshold for intervention.[2,6,9,12–15] Transient neonatal asymptomatic hypoglycemia is believed to be a natural phenomenon occurring in the hours after birth with little effect on overall infant wellbeing.[6,16–18] This glucose nadir may, in fact, be a physiologic trigger that facilitates postnatal adaptation.[2,9,19] Blood glucose levels that are below predetermined cutoff levels often result in the transfer of asymptomatic infants to the NICU for management of their hypoglycemia and potential initiation of more invasive measures to increase blood glucose levels. The transfer of infants in the early hours of life results in the separation of the mother-infant dyad and disruption of bonding that is important for lactogenesis.[5,8,9] Infants who are admitted to the NICU are more likely to undergo venipuncture, be evaluated for sepsis, and initiated on antimicrobial agents.[9,20] Additionally, asymptomatic newborns may be prematurely transferred to the NICU for hypoglycemia that is responsive to feeding or improves physiologically and does not ultimately require interventions such as intravenous dextrose.

Recent literature suggests that the risk of developing neonatal hypoglycemia can be attenuated after birth. Prophylactic measures, such as skin-to-skin care (SSC) after delivery and breastfeeding in the first hour of life, may result in improved glucose homeostasis and prevent hypoglycemia.[4,15,21,22] In particular, SSC has been shown to stabilize glucose, facilitate the initiation of breastfeeding, and prolong breastfeeding duration, which sets the foundation for improved health benefits for the remainder of childhood and beyond.[4,21–23] Delaying the first blood glucose measurement to between 60 and 120 minutes of life may decrease overdiagnosis of the physiologic nadir as clinically significant hypoglycemia without increasing the risk of hypoglycemia complications.[7,8,15]

Our primary objective for this intervention was to reduce the NICU transfer of infants at risk for hypoglycemia by 50% through the standard implementation of nonpharmacologic measures to promote glucose homeostasis, including SSC, early feeding, and attention to feeding measurable amounts when hypoglycemia occurs. We additionally sought to standardize the time of the initial blood glucose measurement of asymptomatic infants to the second hour of life and eliminate unnecessary NICU transfers for infants who ultimately do not require intervention other than feeding.

METHODS

Setting

Our institution is a tertiary-care, academic medical center with multiple subhospitals. Women in the peripartum period and healthy newborns are cared for in the North Carolina Women's Hospital, which is designated Baby Friendly and facilitates ~3600 deliveries per year. The adjoining University of North Carolina (UNC) Children's Hospital is home to a 58-bed, level IV Newborn Critical Care Center (NICU) that cares for >1000 neonates per year. Our facility is a referral center for the region, receiving high-risk mothers and critically ill newborns from all 100 counties in North Carolina and neighboring states. There is no transitional care or level II nursery, and intravenous fluids cannot be administered in the newborn nursery; therefore, newborns are cared for either by newborn nursery staff in their mothers' rooms or by staff in the NICU on a separate floor. The NICU facility does not have private rooms, making it unusual for mothers or fathers to stay continuously with their infants. Because of the high-risk population, many mothers have conditions requiring postpartum management, which hinders visitation on the first day of life.

The protocol for the management of newborns at risk for hypoglycemia at our institution (Supplemental Fig 5) was rigid, complicated, and lacked several American Academy of Pediatrics (AAP) recommendations, including assessment by a licensed independent practitioner (LIP) in management decisions to determine the presence of any modifiable factors for hypoglycemia. A wide range of glucose values triggered the notification of the NICU team for transfer regardless of symptoms, feeding status, or hour of life. The initial blood glucose level was generally obtained within the first hour of life in the labor and delivery ward at a convenient time for staff, leading to variability. There was inconsistent effort and documentation around SSC and feeding during the busy postpartum period as the dyad was prepared to transition to the mother-infant unit. Initial documented feeding was thus unrelated to the time of initial blood glucose testing. Frequent formula and bottle use occurred in newborns who were transferred to the NICU because of dyad separation when breastfeeding was the desired method, leading to the dissatisfaction of both providers and families.

Human Subjects Protection

The UNC Institutional Review Board determined that this project did not meet the criteria for research involving human subjects and granted an exemption of oversight.

Intervention

An interdisciplinary task force was formed in November 2014 to improve the care of newborns at risk for hypoglycemia. The task force members included experts in areas spanning care through the

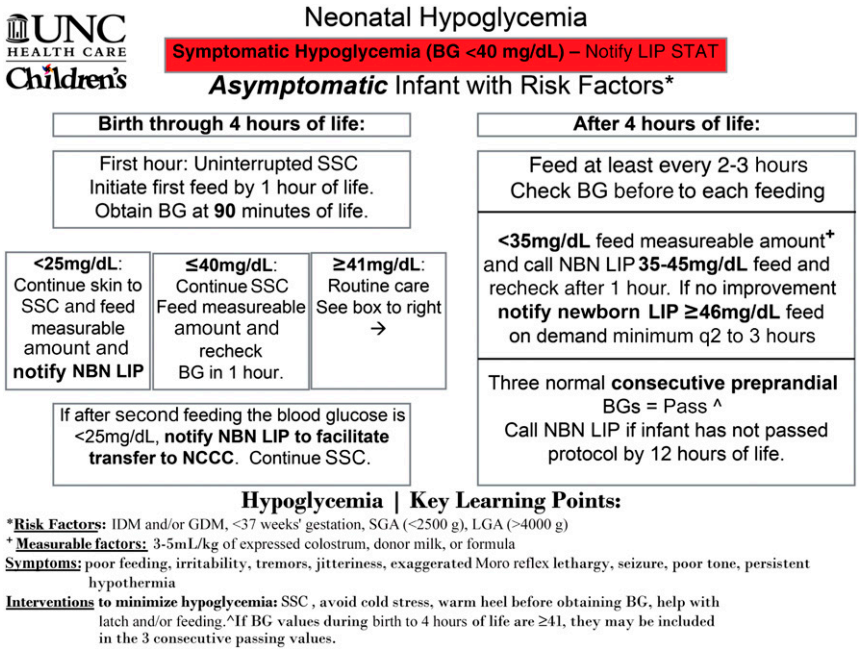

FIGURE 1

New protocol for asymptomatic infants at risk for hypoglycemia. BG, blood glucose; GDM, gestational diabetes; NBN, newborn nursery; NCCC, neonatal intensive care unit; q-2, every 2; STAT, immediately.

peripartum period with providers from obstetrics, pediatrics, neonatology, lactation services, nursing leadership, and nurses from involved units. The task force was charged with standardizing the care of infants who are at risk for hypoglycemia by incorporating the 2011 AAP recommendations and recent literature into an updated protocol to decrease the NICU transfer rate and eliminate the transfer of asymptomatic infants who do not require intravenous dextrose to the NICU.

Together with key stakeholders, the task force developed a hypoglycemia bundle that included a new protocol (Fig 1) and educational efforts to prioritize key prophylactic interventions (SSC, early feeding, and the standardization of initial glucose measurement to after the first feeding) in all infants who are at risk for hypoglycemia. SSC, including in the operating room after cesarean delivery and encouraging the use of a partner if a mother is unable, was particularly emphasized. For clinically stable mothers and infants, interventions disrupting the mother-infant dyad, including measurements, were delayed until 90 minutes of life to encourage uninterrupted SSC. This helped promote the initiation of feeding within the first 60 minutes of life, as is widely recommended.[7,10,24] These interventions were standardized to be the responsibility of the labor and delivery nurse. Additionally, feeding measurable amounts of supplementation with either maternal milk, donor milk, or ready-to-feed 19 kcal/oz formula before considering NICU transfer in asymptomatic infants with hypoglycemia was promoted. Dextrose gel is not currently available at our institution.

Blood glucose level cutoffs and interventions for hypoglycemia were updated to be consistent with the 2011 AAP Clinical Report, including the definition of hypoglycemia as ≤40 mg/dL in the first 4 hours of life and ≤45 mg/dL from 4 to 24 hours of life. Initial blood glucose measurement was standardized to 90 minutes of life in an attempt to allow for the physiologic nadir to occur while also documenting blood glucose, as recommended, 30 minutes after the initial feeding and within 2 hours of birth. The notification of the LIP responsible for the newborn regarding a low glucose level was incorporated, replacing automatic notification to the NICU. All involved units offered feedback and received education regarding the new protocol before the hypoglycemia bundle was implemented in February 2015.

The population in our improvement efforts included inborn infants who were asymptomatic and had at least 1 of the following risk factors for hypoglycemia: IDM, SGA, LGA, or LPT gestation (35 0/7–36 6/7 weeks). Of note, at the time of the intervention, our institution used 2.5 and 4.0 kg as standard cutoffs for the risk factors of SGA and LGA, respectively, regardless of gestational age. Infants were excluded from the standard protocol, and thus the study, if a known congenital anomaly or other condition that required intensive care was present, including being born at <35 weeks' gestation or <2.0 kg, because these infants are routinely admitted to the NICU. Infants with symptomatic hypoglycemia were also not included in the study because the presence of symptoms necessitates different management; however, the incidence of symptomatic hypoglycemia was tracked as a balancing measure and is described below.

Studying the Intervention

Eligible newborns were identified via an institutional deidentified database query as having 3 or more blood glucose measurements during their newborn hospitalizations. The North Carolina Translational and Clinical Sciences Institute

(grant 1UL1TR001111) provided patient medical record numbers via the Carolina Data Warehouse for Health. Patient electronic medical records were then manually reviewed by 3 of the authors and 2 nurses for inclusion criteria and data for the measures identified below. Charts were reviewed retrospectively in weekly increments by 2 independent investigators. Discrepancies in the data collected were resolved by group consensus. Baseline data were collected during a 4-month period from April 2014 to July 2014, just before the initial convening of the task force, and the intervention data were collected during 5 months from March 2015 to July 2015, after the implementation of the hypoglycemia bundle. Basic demographic statistics of the baseline and intervention groups were also collected (Table 1).

During the baseline and intervention periods, there were no other major interventions or practice changes focused on this patient population. Given the known relationship between SSC and improved glucose stabilization, we believe that any observed changes in outcomes can be attributed to our intervention.

Measures

The percent of at-risk infants transferred to the NICU each week was the primary outcome measure of the intervention. Secondary measures included the percent of infants with documented SSC within the first hour of life, the percent of infants with documented feeding within the first hour of life, and the time in minutes to the first blood glucose measurement. The incidence of unnecessary NICU transfer, defined as an asymptomatic infant transferred and ultimately not requiring intravenous dextrose or other intensive care, was also tracked. Data on balancing measures, including the following, were collected to ensure that the intervention did not cause harm: sepsis evaluation, seizure event attributed to hypoglycemia, apnea or event requiring resuscitation, or readmission for hypoglycemia to UNC-affiliated hospitals within 1 week. Additionally, the incidence of symptomatic hypoglycemia in at-risk infants was tracked to monitor for the unintended potential consequence of increasing symptomatic hypoglycemia by adjusting the protocol.

By manually reviewing the charts of all newborns with 3 or more blood glucose measurements (a minimum of 3 adequate glucose levels are required to complete testing), for risk factors of hypoglycemia rather than screening by diagnosis codes, we ensured that no infants were missed because of inappropriate coding. This additionally allowed for a careful observation for exclusion criteria and balancing and safety measures by incorporating a review of clinical documentation.

Analysis

Data analysis was performed by using statistical process control charts and interpreted by using standard Shewhart rules to measure improvement over time in key aims. Separately, time to first glucose measurement was analyzed by using median and interquartile range (IQR) because this best represented the measure given the wide range of and variability in values at baseline.

TABLE 1 Demographic Characteristics of Baseline and Intervention Groups

	Baseline	Intervention
	n = 208	*n* = 270
Characteristic		
Gestational age	39 wk 1 d (±1 wk 4 d)	38 wk 5 d (±1 wk 5 d)
Birth wt	3989 g (±760 g)	3470 g (±785 g)
Risk factor, *n* (%)		
LGA (>4 kg)	104 (50)	114 (42)
IDM	84 (40)	95 (35)
SGA (<2.5 kg)	34 (16)	73 (27)
LPT	27 (13)	53 (20)

Ethical Considerations

The primary ethical concern related to this intervention is the unclear definition of hypoglycemia and the impact on neurodevelopmental outcomes. Thus, the protocol was developed by using existing evidence and recommendations from governing bodies. We used glucose minimums that are thought to provide a margin of safety above the level at which detrimental effects are presumed to occur.[4,5,7,9,15]

RESULTS

Data analyzed included those of 208 at-risk infants in the baseline period and 270 infants born during the improvement period. For the primary outcome, the rate of NICU transfer because of asymptomatic hypoglycemia decreased from a baseline of 17% of at-risk infants to 3% of infants after the improvement initiative, representing a statistically significant decrease over time (Fig 2). Secondary outcomes also demonstrated improvement over time, with the mean percentage of at-risk newborns receiving SSC in the first hour of life increasing from a baseline of 45% to 64% (Fig 3) and infants fed in the first hour increasing from 43% to 61% (Fig 4). There was standardization and delay to initial blood glucose screen, with a baseline median of 65.5 minutes (IQR 50–81), which improved to a

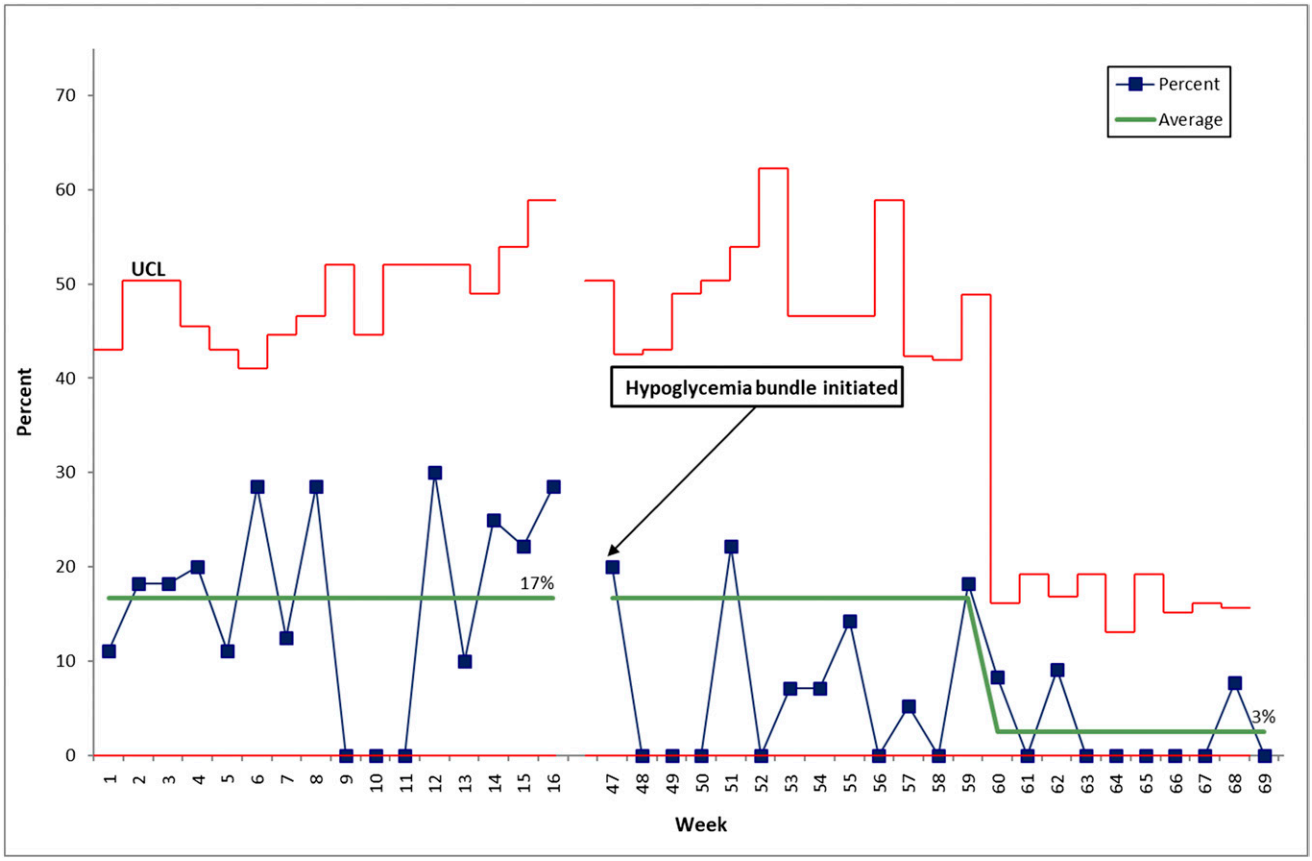

FIGURE 2

P-chart for percent of asymptomatic infants at risk for hypoglycemia transferred to the NICU (data source: Epic and Carolina Data Warehouse for Health). UCL, upper control limit.

median of 95 minutes (IQR 88–102) after the intervention. Unnecessary NICU transfers decreased from 5% (10 of 208) of at-risk infants to 0.7% (2 of 270) after the implementation of the bundle.

The balancing measures that were tracked showed no change in the percentage of at-risk infants developing symptomatic hypoglycemia during the time period after the change in protocol. The rate of sepsis evaluations was similar between the baseline and intervention groups, and there were no seizures, apneas, or readmissions related to hypoglycemia in either group.

DISCUSSION

The implementation of a quality-improvement initiative by a multidisciplinary team was effective in decreasing hypoglycemia requiring NICU transfer in at-risk infants at our institution. In this project, we address a current, important topic and provide reproducible improvement strategies to reduce neonatal hypoglycemia, decrease health care costs, and promote the maintenance of the mother-infant dyad. This was a low-cost, quality-improvement initiative that used the current staffing positions and the best and most natural resource for a newborn: their mother.

We reduced our rate of NICU transfer to 3%, which exceeded our goal of a 50% reduction and achieved a rate much lower than the published national average of a 10% rate of transfer.[1–5] This initiative resulted in >4 in 5 infants who were previously transferred to our NICU remaining in the mother-infant unit with their families. Importantly, the intervention nearly eliminated the transfer of infants to the NICU who did not require any intervention other than feeding. Preventing unnecessary NICU transfers is not only important for families but reduces health care expenditures and improves bed use and access for high-risk maternal and neonatal patients within our institution and region. The estimated cost savings of this intervention, based on the difference between newborn nursery and NICU facility and physician charges, is conservatively estimated to be a minimum of $2500 per infant or ~$100 000 per year at our institution.

This improvement initiative adds to a growing body of evidence that

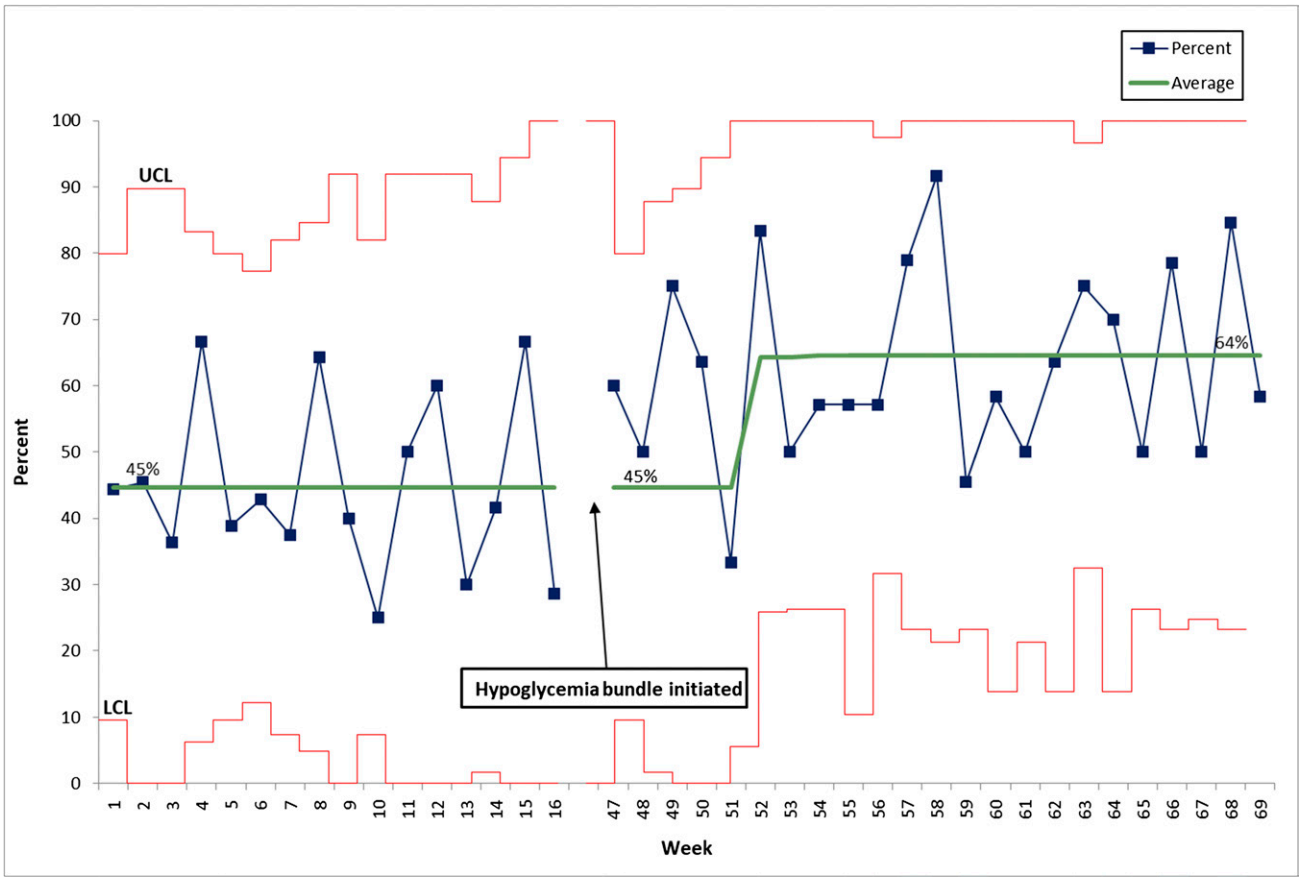

FIGURE 3
P-chart for percent of asymptomatic infants at risk for hypoglycemia placed for SSC in the first hour of life (data source: Epic and Carolina Data Warehouse for Health). LCL, lower control limit; UCL, upper control limit.

nonpharmacologic, prophylactic measures can aid the transition of newborns to extrauterine life. Delaying routine newborn procedures and emphasizing SSC and early breastfeeding before obtaining the initial blood glucose measurement demonstrated to staff and families the importance of these measures in promoting glucose homeostasis and the overall transition to extrauterine life. We saw an immediate improvement in the documentation of both SSC and early feeding from baseline, although SSC demonstrated an earlier signal change at week 52 (10 weeks into the intervention) than for documented feeding in the first hour of life, which occurred at week 60. The signal change in feeding (Fig 4) correlated with the signal change in the reduction of NICU transfer (Fig 2), most likely representing the cumulative effects of culture change over the initial 18 weeks of the intervention and signifying an overall improvement in adherence to the new protocol. Although recent evidence suggests that in healthy term infants, early feeding alone may not significantly alter glucose levels, it remains somewhat unclear how an emphasis on early feeding may impact this at-risk population.[25,26] Given that our interventions could not be implemented sequentially because of a need for an updated protocol, it is more difficult to determine specifically which intervention within the bundle may have most impacted the rate of hypoglycemia requiring transfer to the NICU.

Protocol adherence was additionally demonstrated by the success in shifting the median time for initial blood glucose measurement later by 30 minutes from our baseline of obtaining at ~1 hour of life. Standardizing initial blood glucose measurement in the second hour of life in asymptomatic infants, generally after the physiologic nadir occurs, likely resulted in lower detected rates of hypoglycemia without a resultant increase in symptomatic hypoglycemia or other adverse outcomes. Additionally, incorporating the LIP in the evaluation and management of any newborn experiencing hypoglycemia before NICU transfer likely contributed to staff reassurance and acceptance

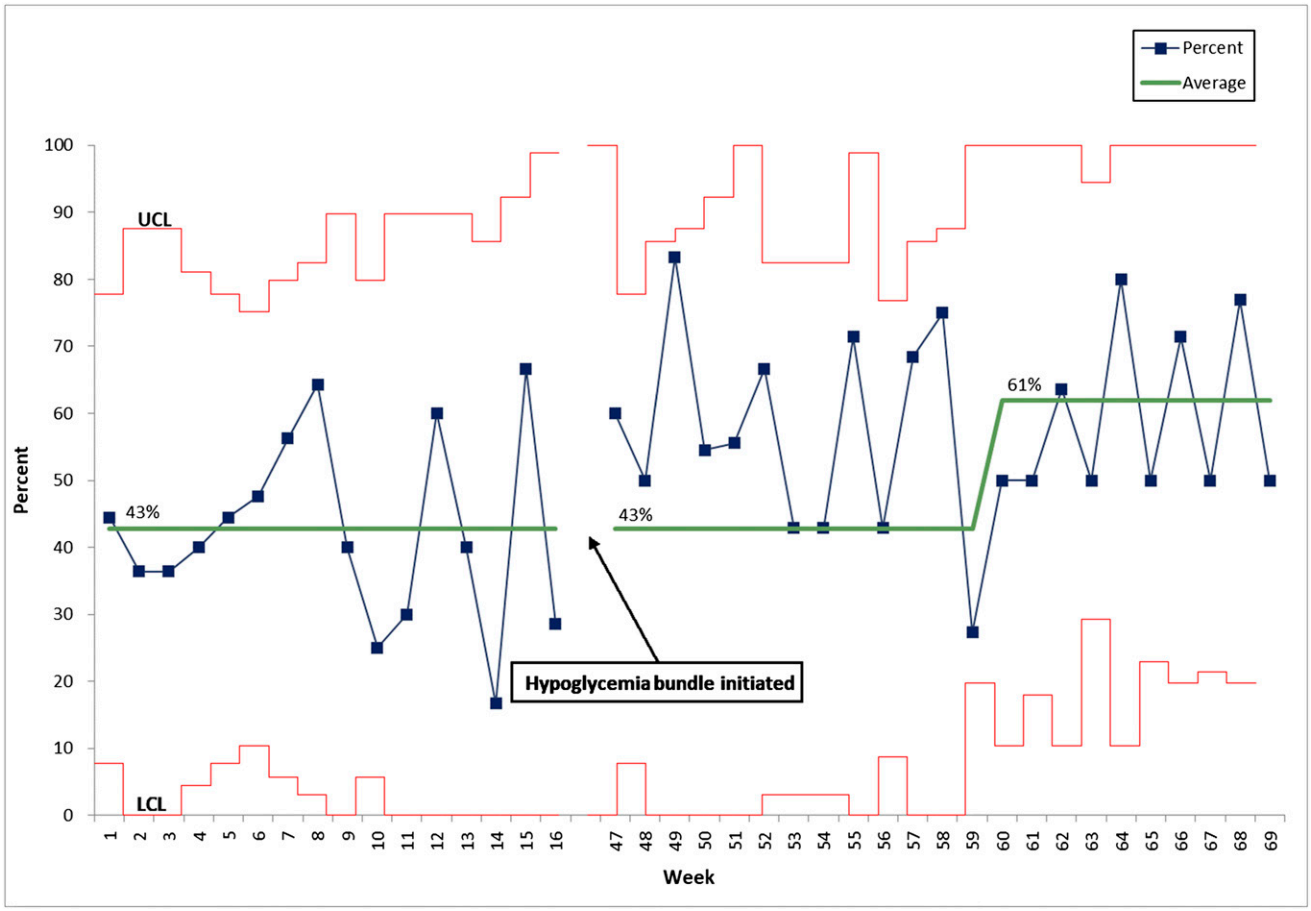

FIGURE 4
P-chart for percent of asymptomatic infants at risk for hypoglycemia fed in the first hour of life (data source: Epic and Carolina Data Warehouse for Health). LCL, lower control limit; UCL, upper control limit.

of the new protocol. LIPs were able to then directly promote supplementation in infants with hypoglycemia for whom it was appropriate to remain with their mothers. There has been recent interest and research around using glucose gel as a means of supplementation, and it has been considered at our institution, although we have demonstrated that NICU transfer can be a rare event in infants who are at risk for hypoglycemia without its use.[26–28]

Limitations

Limitations of this project include that it is a single-center study at an institution with a high-risk perinatal population and no level II newborn unit, so generalizability of results may be limited to similar institutions. Because of institutional and electronic medical record constraints on data retrieval and project implementation, there was a delay between the baseline data used to initiate the formation of a project team and charter and the actual beginning of interventions and collection of weekly data during the improvement period, which is represented by the gap between the baseline group and the implementation group on the process control charts. Although this is not ideal, the maintenance of the baseline mean for several weeks into the improvement period supports that the baseline cohort adequately represents the current state at the time of the implementation of the hypoglycemia bundle. Data for SSC and feeding time relied on nursing documentation and manual chart review, both of which have inherent limitations. Focusing on these measures may have improved documentation alone, although retrospective reliance on documentation during the busy postpartum period also likely greatly underestimated their occurrence. However, the time of the first blood glucose measurement and transfer to the NICU are objective measures that are not impacted by these documentation factors.

Future Research

In the spirit of quality improvement, data collection was focused on

measurable outcomes related to our key aims. Thus, we did not collect data on the rate of occurrence of hypoglycemia, the degree of hypoglycemia, the number of blood glucose measurements necessary to pass the protocol, breastfeeding rates, or maternal satisfaction overall. Future research will assess these measures because we suspect that maintaining the mother-infant dyad in these high-risk cohorts positively impacted many of these factors and improved overall satisfaction during hospitalization.

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ABBREVIATIONS

AAP: American Academy of Pediatrics
IDM: infant of a mother with diabetes
IQR: interquartile range
LGA: large for gestational age
LIP: licensed independent practitioner
LPT: late preterm
SGA: small for gestational age
SSC: skin-to-skin care
UNC: University of North Carolina

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