Infant-Led Incubator Weaning

A Promising Paradigm Shift in Preterm Neonatal Care

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ABSTRACT

Background: Thermoregulation is paramount in preterm infant care, traditionally addressed through nurse-led incubator weaning protocols. Recent research has introduced infant-driven incubator protocols that are demonstrating promise.

Purpose: This study, conducted at a freestanding academic pediatric hospital in the mid-Atlantic, examined the impact of infant-led incubator weaning on a specific neonatal cohort. The primary hypothesis posited that infants in the infant-led weaning group would wean out of the incubator at earlier gestational ages and lower weights, while maintaining comparable or greater weight gain during the transition to open cribs.

Methods: A retrospective chart review compared 40 infants weighing less than 1500 g before and after a weaning protocol change.

Results: Infant-led weaning demonstrated lower weights at weaning to crib (M = 1836.80 g) compared with nurse-led weaning (M = 1975.9 g), with statistical significance (t [36] = 2.27, P = .02, Cohen's d = 0.74). Infants in the infant-led group had a lower weight change 5 days prior to weaning (M = 141 g) compared with the nurse-led group (M = 185 g), which is also statistically significant (t [36] = 1.93, P = .03, Cohen's d = 0.63). T-tests revealed no significant differences in gestational age at wean to crib, change in weight post-weaning, gestational age, or days to discharge.

Implications for Practice and Research: Infant-led weaning emerges as a safe alternative with potential benefits for preterm neonates and their families. While initial positive outcomes are evident, further research with a larger neonatal cohort is imperative to validate the efficacy of infant-led weaning as a successful alternative to traditional methods.

Key Words: body temperature regulation, infant equipment, intensive care unit, isolette, neonatal, weaning

Thermoregulation is a paramount concern in the care of preterm infants due to their susceptibility to temperature instability because of limited body fat and underdeveloped mechanisms to sustain temperature.[1] Maintaining an appropriate environment for the neonate helps prevent complications resulting from hypothermia, which can lead to respiratory distress, metabolic issues, and increased energy expenditure.[1,2] Incubators are an essential tool for ensuring thermoregulation in preterm infants, creating a controlled environment that supports infant's growth and is considered critical to their well-being. While the incubator provides a controlled environment with decreased noise and stimulation that benefits the immature preterm infant, as they grow and mature, their developing brains benefit from increased stimulation obtained outside the incubator. Exposure to natural environmental stimuli, such as sounds, sights, and interactions, is crucial for their sensory and cognitive development, helping them adapt and thrive in a more typical environment as they become ready for discharge.[3,4] Studies suggest that early weaning from the incubator can lead to earlier achievement of full volume oral feeds, improved weight gain, and shorter length of hospital stay.[5-7]

Nurse-led weaning relies on nurse speculation and drives the process for the infant to come out of the incubator, while infant-led weaning utilizes infant thermoregulation as a self-directed indicator of readiness.[8] This study is a comparison of infant outcomes by nurse-led and infant-led incubator weaning methods. Additionally, this manuscript discusses the feasibility and potential benefits of implementing an infant-led incubator weaning protocol in a Level IV NICU population. We hypothesized that the infant-led weaning group would wean at a lower gestational age and weight and would have comparable or greater weight gain once transitioned to the open crib.

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What This Study Adds

- Infant-led weaning from the incubator is a safe alternative to traditional nurse-led methods of weaning out of the incubator.
- Infant-led incubator weaning could reduce nursing task dependence and promote parent-infant bonding, ultimately enhancing the quality of care for preterm neonates in the NICU.

LITERATURE REVIEW

Weaning from the incubator to a crib or even a warmer increases the infants metabolic demands that can lead to decreased weight gain and stress in the infant.[2,9] This stress is important because it can delay infant growth and increase length of stay.[1,2] Seminal work by Medoff Cooper helped standardize nurse-driven protocols in weaning infants out of incubators by providing evidence-based guideline on how to safely transition infants to open cribs. Her research identified key indicators such as body temperature regulation, weight gain, and overall physiological stability that are necessary for a successful transition from the incubator. This helped NICUs to develop a more streamlined approach to weaning, ensuring that infants are not moved prematurely, which could risk hypothermia or other complications.[10] Multiple studies over the last 2 decades have examined the optimal weight or gestational age at which infants are ready to wean out of the incubator. Despite this, there is still variation in practice concerning the optimal weight, postmenstrual age (PMA) to initiate the process, and the appropriate thresholds for incubator air temperature and body temperature before moving to an open crib.[5-8,11]

Historically, nurse-led weaning protocols have been the cornerstone of thermoregulation in neonatal intensive care units (NICU), involving adjustments in ambient temperature while monitoring neonatal temperature and weight gain to lead the infant to reside in an open crib.[8] Recent research presented by Schwoebel et al and others proposes an alternative "infant-led" weaning process.[12] However, to our knowledge no other published studies have examined an infant led weaning protocol.

METHODS

This study was reviewed by the Nemours Institutional Review Board and determined to be exempt. This retrospective study was conducted at a freestanding pediatric academic quaternary-care NICU in the Mid-Atlantic region of the United States. We examined differences in infants pre- and post-transition from nurse-led incubator weaning to an infant-led protocol. At our institution, the nursing-led weaning procedure for transitioning infants from an incubator began once infants met the following criteria: weight of greater than 1600 g, consistent weight gain, absence of apnea or bradycardia, and a stable medical condition. The infant was dressed in a t-shirt and sleep sack, and the incubator was changed from infant servo-control (ISC) mode to air mode. To initiate the transition, the ambient temperature was reduced by 0.5 °C every 12 hours—provided the patient tolerated the wean—with the goal of gradually acclimating the infant to room temperature. Transition to an open crib was considered successful when the infant maintained temperature stability (axillary temperature >36.5 °C) and the ambient temperature was 28 °C for a continuous 24-hour period.

Our updated, infant-led incubator weaning procedure also involved specific criteria to ensure a smooth transition. The infant must have demonstrated consistent weight gain, weighed more than 1500 g, had an absence of apnea or bradycardia, and had an axillary temperature between 36.5 and 37.5 °C, before the transition process could begin. The infant's upper extremities were swaddled in a light blanket, and they remained on the ISC mode. If an infant is fully dressed and bundled inside the incubator, the body doesn't properly adjust to regulate temperature in a less controlled environment. Similarly, when weaning infants from the incubator, using blankets and appropriate clothing helps keep them warm as they transition to maintaining body temperature outside of the incubator, just as you rely on your coat for warmth when stepping outside. The weaning process progressed when the ambient temperature in the incubator did not exceed 28 °C (room temperature) for at least 24 hours. If an infant was not ready to move to an open crib, their inability to maintain goal body temperature would drive up the ambient incubator temperature as needed to support them. Once this goal was met, the infant was placed into an open crib fully dressed and swaddled. Transition from incubator to crib was also considered successful when the infant maintained temperature stability and the ambient temperature reached 28 °C for a continuous 24-hour period.

Our nurse-led protocol followed the recommendations from Medoff-Cooper's research on transitioning preterm infants to an open crib.[10] Our infant-led protocol followed the guidelines used by Schwoebel in her research.[12] We did implement one change, which was to use a light blanket to provide neurodevelopmental support to the infant with swaddling, whereas Schwoebel's' study protocol dressed the infant in just a light t-shirt.[12] The parameters needed to initiate the weaning process for both protocols were the same as those recommended by the National Association of Neonatal Nurses

(NANN) per the Thermoregulation in the Care of Infants Guideline for Practice,[13] with the exception of a decrease in the weight goal for the infant-led protocol. This change was implemented to potentially allow some infants to wean to crib at a lower weight.

Prior to April 2022, our unit employed the traditional nurse-led weaning protocol. In March 2022, after a literature review and in collaboration and consultation with NICU team stakeholders, we implemented a comprehensive educational intervention to facilitate the adoption of the new infant-led protocol for incubator weaning. Education to staff included a PowerPoint presentation with step-by-step instructions followed by mandatory face-to-face training sessions conducted by a team of experts trained in the new procedure, who served as ongoing resources for staff questions. The educational plan was followed by a practice change involving transition from nurse-led weaning to the infant-led process. This practice change was a written protocol and included infant-specific guidelines and exclusion criteria.

Patient data for the 2 protocols were evaluated through a retrospective chart review. We reviewed records of 20 infants weaned in the month prior to our protocol change under the nurse-led protocol, followed by 20 infants weaned 1 month after implementing the infant-driven model. Our study size was based on the average number of infants born under a birth weight of 1500 g that are admitted to our unit in 1 year. Infants were excluded if transferred to another hospital before completing the weaning process or if their illness necessitated a shift from a heated incubator to a radiant warmer. Infants who were included in our study needed to meet the criteria of being born prior to 32 weeks and with a birth weight of less than 1500 g. Infants needed to be in-patient at our facility throughout the entire transition from incubator to open crib.

The primary outcomes of interest were gestational age, weight at transition to open crib, duration of open crib stay before discharge, and growth velocity before and after placement in open crib (weight change 5 days pre- and post-transition). These variables were chosen to assess which weaning method facilitated earlier crib transition, potentially leading to a shortened length of stay. The weight change measurement aimed to determine if infants' growth velocity improved after open crib placement, consistent with existing research suggesting weight gain advancements upon reaching the crib.[6]

Statistical analysis examined mean differences between the 2 groups of infants. Based on preliminary examination of data for outliers using the Tukey (1977) method, we identified and removed 6 data points outside the interquartile range. Results of the Shapiro-Wilk normality test showed that the distribution was not normal for gestational age for nurse-led weaning (SW = 0.89, P = .03) and the number of days from open crib to discharge (SW = 0.89, P = .03). Results of Levene's test for equality of variance showed that variance was not equivalent for the infants' weight 5 days after weaning (F = 5.44, P = .03). To test the hypothesis that the infant-led weaning group will wean at lower gestational ages and weight and would have comparable or greater weight gain when in an open crib, Mann-Whitney U-tests were employed for gestational age, days from open crib to discharge, and change in weight 5 days after weaning, which were determined to be nonparametric variables. Independent sample t-tests were used for weight at weaning to crib, gestational age at weaning to crib, and change in weight 5 days prior to weaning, variables which met assumptions of equality of variance and normal distribution.

RESULTS

A total of 40 infants were compared by protocol group. The groups were similar with a ratio of 75% male to 25% female (see Table 1). Both groups also had a variety of surgical diagnoses and required variable respiratory support mechanisms at the time of weaning. A summary of group data and t-test results related to the outcomes of interest are shown in Table 2, and result trends are visually depicted in Figures 1, 2, and 3.

Our hypothesis was partially supported. Infants who received infant-led weaning had lower average weight at weaning to crib (M = 1836.80 g) compared with infants who received nurse-led weaning (M = 1975.85 g), t (36) = 2.27, P = .02, Cohen's d = 0.74 (Figure 1). Infants who received infant-led weaning had lower average weight change 5 days prior to weaning (M = 141.25) than infants who received nurse-led weaning (M = 185.00), t (36) = 1.93, P = .03, Cohen's d = 0.63 (Figure 2).

Gestational age for the nurse-led group at wean to crib was M = 36.37 weeks, with a range of 32 5/7 to 41 2/7 and for the infant led group was M = 33.29 weeks, with a range of 32 5/7 to 40 2/7 (Figure 3). T-tests indicated that there was no difference between the 2 groups for gestational age W = 134.5, P = .96, or at gestational age at wean to crib, t (38) = 1.58, P = .06. Similarly, no difference was noted in the weight change 5 days after weaning to an open crib W = 121.00, P = .98. The nurse led group had a M = 112.3 g, with a range of 30 to 290 g. and the infant led group had a M = 148.75 g and a range of 35 to 305 g of weight gain in the 5 days after weaning. Finally, the average days from open crib to discharge was 8 to 130 days for the nurse-led

TABLE 1. Demographic Information Compared by Protocol Group

	Nurse-Led Group	Infant-Led Group
Sex		
Female	5	6
Male	15	14
Primary Diagnosis[a]		
Prematurity	7	9
Surgical necrotizing enterocolitis	5	5
Medical necrotizing enterocolitis	3	0
VP shunt	5	5
Genetic syndrome	2	1
Pyloric perforation	0	1
Tracheostomy	1	1
Transesophageal fistula	1	0
Respiratory Support Needs		
Room air	5	9
Nasal cannula	1	0
Vapotherm	8	4
NCPAP	4	6
Ventilator	2	1

[a]Total primary diagnosis is greater than 20 as some infants had 2 primary diagnosis listed.

group (M = 55.65) and 4 to 159 days (M = 56.35) for the infant-led group with no statistical difference between groups W = 204.00, $P = .35$.

DISCUSSION

Infant-led weaning marks a transformative shift in the paradigm of thermoregulation for preterm neonates. It recognizes the inherent individuality of each patient, tailoring the weaning process to their specific journey and readiness. Beyond the realm of thermoregulation, this approach holds significant promise for nurturing parent-infant bonding, enhancing parental satisfaction, and potentially facilitating earlier discharges.[14] While our study offers initial evidence of its advantages, comprehensive, large-scale research remains crucial for fully validating its effectiveness. When beginning this study, the team hypothesized that even if outcome measures remained equivalent between the 2 weaning protocols, the infant-led approach may demonstrate its safety and suitability for NICU implementation as a viable alternative. However, we did find promising results that may provide long-term benefits.

Importantly, we found that infants in the infant-led group had lower weight at transition and more consistent weight gain compared with infants transitioning during the nurse-led protocol. An infant in an open crib gets more sensory stimulation, which is essential for neurological and cognitive growth. Research has shown that infants in open cribs are exposed to higher speech counts when compared with infants in incubators.[15] Early interactions with parents promote emotional bonding, fostering a secure attachment that positively influences a child's social and emotional well-being.[16-18] Moreover, when an infant is in a crib, parents can take on a more active role in caregiving. Speculation around why this occurs could be that caregivers now view the infant as "a normal baby," and it also becomes easier to transfer and hold their infant.[19] Additionally, without the physical barrier of an incubator, parents may be more likely to engage with their infant. Increased parental involvement in care increases the parental bond and the parent's confidence in their parenting skills.[14,20]

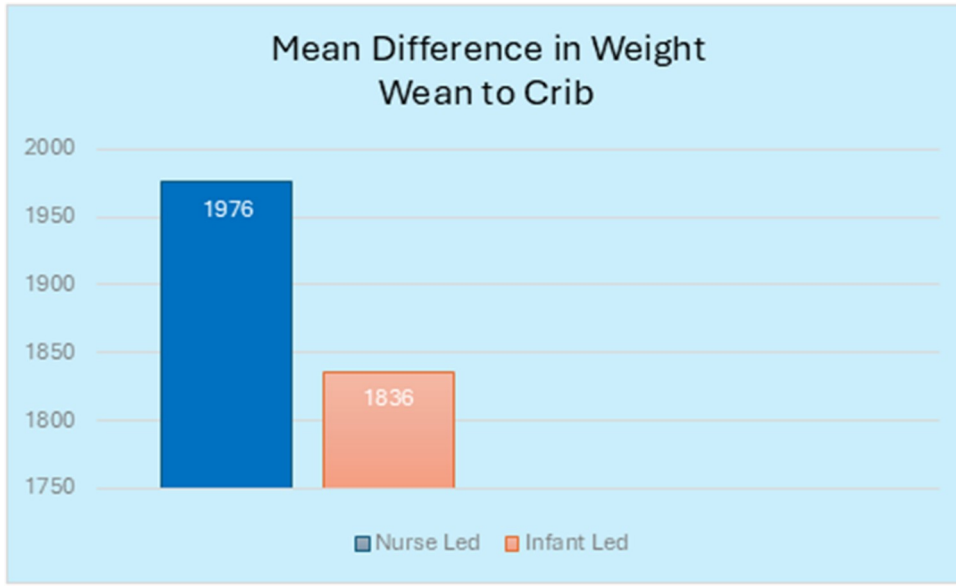
While results were not statistically significant, the infant-led group tended to wean at a slightly younger age and demonstrated greater weight gain after 5 days in an open crib. These findings should be examined in a larger cohort to see if sample size could identify significance and confirm our findings. This could lead to enhanced parent-infant bonding and earlier discharge to home. Additionally, we

TABLE 2. Descriptive Statistics of Study Variables

	Nurse-Led ($n = 20$) M(SD)	Infant-Led ($n = 20$) M(SD)	*P* Value
Gestational age at birth (weeks)	26.60 (2.00)	28.51 (3.42)	.96
Weight at weaning to crib (grams)	1975.85 (240.82)	1836.80 (206.33)	.02
Gestational age at weaning to crib (weeks)	36.37 (2.14)	35.31 (2.10)	.06
Change in weight 5 days prior to weaning (grams)	185.00 (99.44)	141.25 (77.23)	.03
Change in weight 5 days after weaning (grams)	112.30 (63.25)	148.75 (75.83)	.98
Days from open crib to discharge (days)	55.65 (35.87)	56.35 (35.78)	.35

Note: Descriptive information is separated between the 2 groups. Six data points were removed because they were identified as outliers.

FIGURE 1

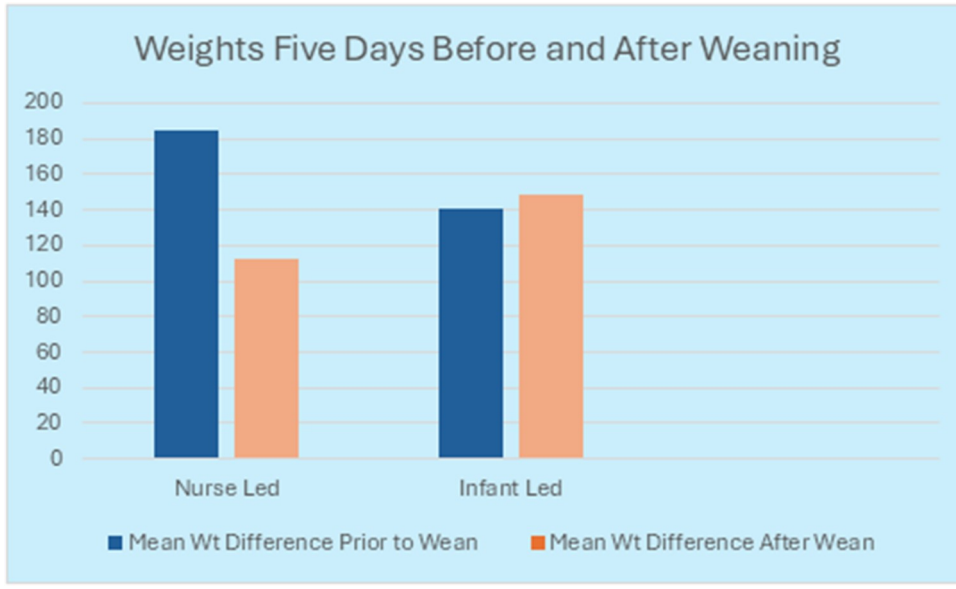


Mean difference in weight wean to crib.

could not find significance in failure rates, but these findings could also be enhanced with additional study to ensure that infant led weaning is the safest and most beneficial to NICU infants.

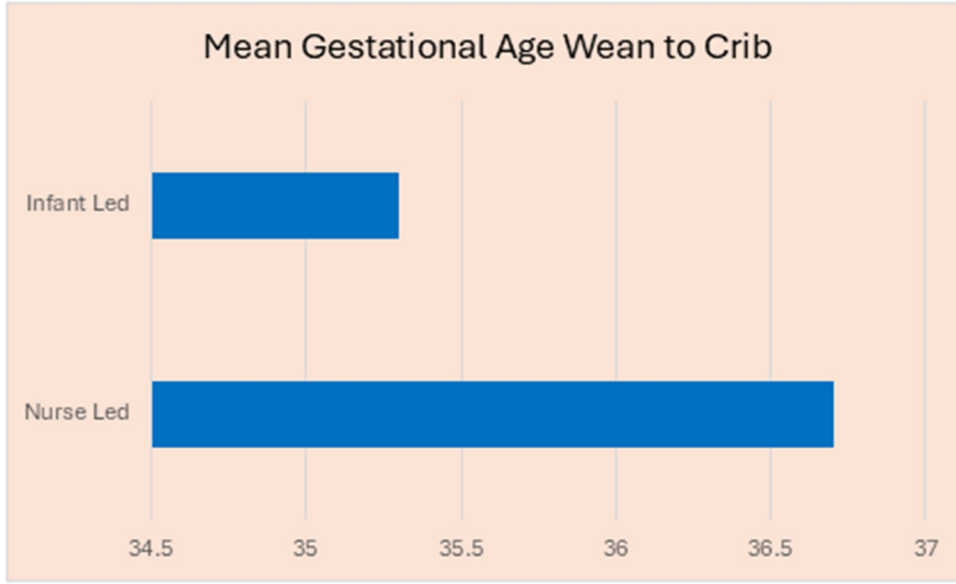
While our study provides preliminary evidence for the potential benefits of infant-led weaning in a level IV NICU setting there are important limitations that require additional research. Additional studies could examine NICU settings with a higher proportion of premature infants to confirm and generalize these findings. While we did include detailed criteria for infants who could be weaned, the sample size was small,

FIGURE 2



Weights 5 days before and after weaning.

FIGURE 3



Mean gestational age wean to crib.

limiting the implications of the findings. In addition, our sample groups were 75% male, and new studies could examine a more heterogeneous sample and quantitatively compare infant-led and nurse-led acuity more precisely. For example, NICU settings with less-complex patient populations may experience even shorter lengths of stay with this protocol. Future investigations should explore average daily weight gain, total length of stay, and long-term outcomes, such as parental bonding and satisfaction, to gain a holistic view of the potential advantages of this approach.

Allowing neonates to indicate readiness for incubator weaning has the potential to transform family-centered care and overall enhance NICU experience. This approach could reduce nursing task dependence and promote parent-infant bonding, ultimately enhancing the quality of care for preterm neonates in the NICU.

Our study supports the safety and potential benefits of infant-led weaning as an alternative method for weaning preterm neonates from incubators to open cribs. Despite differences in weight at weaning and weight change before weaning, there were no significant differences in other critical outcomes between the 2 groups. Moreover, the trend toward earlier weaning and improved weight gain in the infant-led group suggests potential advantages for both neonates and their families.

Summary of Recommendations for Practice and Research	
What we know:	• Incubators are an essential tool for ensuring thermoregulation in preterm infants, creating a controlled environment that supports infant's growth and is considered critical to their well-being. • Prolonged length of time spent in an incubator has potential disadvantages including being a barrier to parent/child bonding and contributing to developmental delays related to limited sensory stimulation. • Studies suggest that early weaning from the incubator can lead to earlier achievement of full volume oral feeds, improved weight gain, and shorter length of hospital stay.[5-7]
What needs to be studied:	• What are the long-term developmental outcomes of infant led incubator weaning? • Does infant led incubator weaning improve parental bonding and satisfaction? • Do results from this study replicate in larger cohorts of premature infants?
What can we do today:	• Gather baseline data on infants weaned from incubators. • Develop clear criteria and guidelines for infant readiness to wean from incubator. • Develop and deliver comprehensive education to staff regarding guidelines and criteria for infant led weaning. • Provide ongoing assessment of weaning practices and monitor for any complications or challenges in the process.

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