Early Weaning From Incubator and Early Discharge of Preterm Infants: Randomized Clinical Trial

OBJECTIVE: The goal was to assess the feasibility of earlier weaning from the incubator for preterm infants.

METHODS: This was a prospective, randomized study with preterm infants with birth weights of <1600 g who were admitted to a neonatal subintensive ward. Findings for 47 infants who were transferred from an incubator to an open crib at >1600 g (early transition group) were compared with those for 47 infants who were transferred from an incubator to an open crib at >1800 g (standard transition [ST] group). The primary outcome of the study was length of stay. Secondary outcomes were the number of infants returned to an incubator, the growth velocity in an open crib and during the first week at home, the proportions of breastfeeding at discharge and during the first week at home, and the hospital readmission rate.

RESULTS: The length of stay was significantly shorter in the early transition group than in the standard transition group (23.5 vs 33 days; P = .0002). No infants required transfer back to the incubator. Only 1 infant in the standard transition group was readmitted to the hospital during the first week after discharge. Growth velocities and individual amounts of breastfeeding were similar between the 2 groups.

CONCLUSION: In this study, weaning of moderately preterm infants from incubators to open cribs at 1600 g was safe and resulted in earlier discharge. Pediatrics 2010;126:e651–e656
Preterm delivery rates have been reported to be 12% to 13% in the United States and 5% to 9% in Europe and other developed countries.1 The ability to achieve stable temperature in an open crib, together with feeding competency and an absence of medical illnesses and social risk factors, is one main requirement for the discharge of preterm infants.2,3 Guided by concerns about thermal instability and poor weight gain, traditional incubator weaning regimens have advocated weight cutoff values between 1800 and 2000 g. However, weaning to an open crib at lower weights may result in earlier discharge, which facilitates family bonding and prevents overcrowding. Earlier discharge also contributes to the reduction of healthcare resource utilization, provided that patients are not readmitted to the hospital.4–6 Although it is important that preterm infants be discharged from neonatal units as early as safe discharge is possible, discharge patterns still vary between different institutions.7–9

The recent Cochrane review by New et al10 concluded that there is currently little evidence from randomized trials to inform practice regarding the preferred weight for transfer of preterm infants from incubators to open cribs and that there is a need for larger, randomized, controlled trials to address this deficiency. Our study was designed to compare outcomes for infants transferred from an incubator to an open crib at lower (1600 g) versus higher (1800 g) body weight. The former weight threshold was taken from occasional reports regarding its feasibility and safety,11,12 and the latter was taken from the weaning guidelines of our division over the previous 3 years. The aim of the study was to verify the following hypotheses: (1) length of stay (LOS) would be significantly shorter for infants transferred to an open crib at 1600 g and (2) the number of infants with adverse outcomes (lower growth velocity [GV], breastfeeding failure, return to an incubator, or hospital readmission) during the first week after discharge would not be higher for infants transferred to an open crib at 1600 g.

METHODS

Design and Setting

This prospective, randomized, clinical study was conducted between January 1, 2008, and June 30, 2009, in the neonatal subintensive ward of our university hospital and was approved by our institutional review board. Admission criteria for our unit are as follows: (1) birth weight of >750 g, (2) gestational age (GA) of >26 weeks, and (3) no need for assisted ventilation. Written consent was obtained from parents before enrollment. Only preterm infants who were admitted to our unit with birth weights of <1600 g were eligible for the study. Inclusion criteria included weight of ≥1600 g at enrollment, medically stable condition (normal temperature, no apnea, and no sepsis), no phototherapy requirement, and stable or increasing weight at >48 hours. Infants with major congenital abnormalities at birth and infants who required respiratory support (continuous positive airway pressure or oxygen therapy) at the time of random assignment were excluded from the study. Infants included in the study were assigned randomly, at their first day in the open crib. Newborns were the number of infants returned to an incubator, the GV from transfer to an open crib to discharge and during the first week at home, the mean individual amount of breast milk divided by the total amount (breast milk plus formula) that each patient was receiving at discharge and during the first week at home, and the hospital readmission rate.

Procedure

From birth to the targeted body weight, all infants were nursed in incubators with servo-control of temperature and 60% relative humidity. Enteral feeding with breast milk was initiated within the first 2 hours of life. Parenteral glucose administration was added when indicated, according to an individualized regimen that enabled the fluid intake to be increased progressively from 60 to 150 mL/kg per day. Systemic blood pressure, heart rate, respiratory rate, arterial oxygen saturation (measured through pulse oximetry), and urinary output were monitored daily and recorded until the second day in the open crib. Newborns of <32 weeks of gestation received caffeine until 48 hours before expected...
weaning from the incubator or after 1 week without documented apnea.

After transition to an open crib, infants were assisted with 24°C environmental temperature and 40% relative humidity and were dressed in a woolen hat, booties, 2 vests, and a cotton wrap. The axillary temperature was measured hourly until the recording of 2 consecutive readings of $\geq 36.5^\circ$C, which is the normal axillary temperature in an open crib according to the American Academy of Pediatrics/American College of Obstetricians and Gynecologists perinatal guidelines. If the temperature was $< 36.5^\circ$C, then an additional wrap was added to the infant and the temperature was checked after 2 hours. If the temperature remained at $< 36.5^\circ$C, then the infant was transferred back to an incubator. For infants who remained in an open crib, the axillary temperature was measured every 3 hours at feeding time, up to 72 hours after transfer. During this period, if the axillary temperature was $< 36.5^\circ$C in 2 consecutive readings, then the infant was transferred back to an incubator. All studied infants were weighed daily, naked, before the 9:00 AM feeding. A single investigator (Dr. Priolo) recorded the daily weight and breastfeeding amount for each patient in a specific database, from transition to discharge. Growth velocity (GV) was calculated according to the exponential model proposed by Patel et al.

Discharge criteria were full feeding competency (breathe or bottle sucking), normal weight gain in an open crib, axillary temperature of $\geq 36.5^\circ$C after 72 hours, and no apneic episodes after 72 hours without caffeine. A single investigator (Dr. Priolo), who was not aware of the treatment allocation, performed a short-term follow-up assessment after discharge home, recording the data in a specific database. Four days after discharge, the following information was collected during a telephone call: body weight, amount of breastfeeding, general wellness of the infant, and whether the infant had required health care resources such as hospital readmissions, physician visits, or emergency department visits. The same information was collected 7 days after discharge, when the infants were seen in our pediatric ambulatory care facility.

**Statistical Analyses**

Statistical analyses were performed with Microsoft Excel 2003 (Microsoft, Redmond, WA) and SPSS for Windows 17.0 (SPSS, Chicago, IL). We used Student’s $t$ test for normally distributed continuous variables and the $\chi^2$ test for categorical variables. The Wilcoxon rank sum test was used to analyze differences in LOS, which was not normally distributed. $P$ values of $< .05$ were considered to be statistically significant.

### RESULTS

Of 99 eligible infants, 94 were enrolled in our study. We excluded 3 newborns with major congenital abnormalities and 2 infants requiring respiratory support (continuous positive airway pressure or oxygen therapy) at the time of random assignment. We included 47 infants in each group, on the basis of the sample size calculations, and complete data were available for all of them. Table 1 shows baseline characteristics of the infants included in each group. GAs and birth weights were almost equal. Only 1 of the patients in each group had a GA of $< 28$ weeks at birth. Female gender was more prevalent in both groups, and the incidences of small-for-GA infants were similar throughout. Table 2 presents a comparison of relevant data recorded from incubator weaning to discharge. Weight at transfer to an open crib was significantly lower in the ET group than in

### Table 1: Baseline Characteristics of Studied Newborns

<table>
<thead>
<tr>
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<th>ET Group</th>
<th>ST Group</th>
<th>$P$</th>
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</thead>
<tbody>
<tr>
<td>GA, mean ± SD (wk)</td>
<td>32.2 ± 1.7 (27–35)</td>
<td>32.0 ± 1.7 (27–35)</td>
<td>.53</td>
</tr>
<tr>
<td>Birth weight, mean ± SD (g)</td>
<td>1378 ± 208 (840–1590)</td>
<td>1360 ± 188 (1010–1595)</td>
<td>.66</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>17 (35)</td>
<td>22 (47)</td>
<td>.26</td>
</tr>
<tr>
<td>Small for GA, n (%)</td>
<td>15 (32)</td>
<td>13 (28)</td>
<td>.82</td>
</tr>
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### Table 2: Comparison of Relevant Data From Incubator Weaning to Discharge Home

<table>
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<tr>
<th></th>
<th>ET Group</th>
<th>ST Group</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight at transition to open crib, mean ± SD (g)</td>
<td>1638 ± 25 (1600–1890)</td>
<td>1851 ± 29 (1800–1890)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Time spent in open crib, mean ± SD (d)</td>
<td>6 ± 3 (2–17)</td>
<td>6 ± 2 (2–15)</td>
<td>.51</td>
</tr>
<tr>
<td>LOS, median (interquartile range), d</td>
<td>23.5 (19–30.5)</td>
<td>33.0 (27–44.5)</td>
<td>.0002</td>
</tr>
<tr>
<td>Weight at discharge, mean ± SD (g)</td>
<td>1842 ± 126 (1680–2315)</td>
<td>2067 ± 134 (1855–2410)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Postmenstrual age at discharge, mean ± SD (wk)</td>
<td>35.6 ± 1.5 (33–41)</td>
<td>37.0 ± 1.1 (34–40)</td>
<td>.0006</td>
</tr>
<tr>
<td>GV, mean ± SD (g/kg per d)</td>
<td>19 ± 5 (12–39)</td>
<td>22 ± 16 (3–55)</td>
<td>.15</td>
</tr>
<tr>
<td>Individual amount of breastfeeding at discharge, mean ± SD, %</td>
<td>43 ± 31</td>
<td>46 ± 29</td>
<td>.60</td>
</tr>
</tbody>
</table>
the ST group (23.5 vs 33 days; \( P = .0002 \)). As a consequence, the weight (1842 ± 126 vs 2067 ± 134 g; \( P < .0001 \)) and the postmenstrual age at discharge (35.6 ± 1.5 vs 37.0 ± 1.1 weeks; \( P = .0006 \)) also were significantly lower in the ET group. GV was 19 ± 5 g/kg per day in the ET group and 22 ± 16 g/kg per day in the ST group. Rates of breastfeeding (exclusively or in part) at discharge were 75% in the ET group and 77% in the ST group. We found no significant difference with regard to the mean individual amount of breastfeeding at discharge (ET group, 43%; ST group, 46%). Four infants in each group required an additional wrap to maintain normal temperature after transition to an open crib. Two of those infants in the ET group and 1 in the ST group also required a radiant warmer. No infants required transfer back to an incubator. Table 3 presents a comparison of relevant data detected during the follow-up week. The 2 groups had similar GV values (14–16 g/kg per d), both in the first 4 days and in the entire week after discharge. Having maintained the same GV, the ET group still had weights significantly lower than those of the ST group at 4 and 7 days after discharge. The mean individual amount of breastfeeding remained constant after discharge in both groups (ET group, 43%; ST group, 46%). No infants required emergency department visits or unplanned physician visits. Only 1 infant from the ST group was readmitted to the hospital during the week after discharge.

**DISCUSSION**

This study demonstrated that a policy of weaning moderately preterm infants from incubators at a body weight of 1600 g versus 1800 g was safe and reduced the average LOS by 9.5 days. The time spent in an open crib after weaning from the incubator was the same in the 2 groups, which suggests that the reduction in LOS was attributable to the early weaning protocol. None of the infants required transfer back to an incubator, and we found no adverse effects on growth or the ability to breastfeed.

Reduction of LOS is an important goal to be achieved for preterm infants, because early discharge is beneficial to the family, prevents overcrowding, and has important economic implications.\(^{4,5,14}\) However, LOS findings are usually highly skewed, and strategies to reduce LOS may differ among institutions.\(^{15}\) Although the ability to maintain a normal temperature when transferred to an open crib is one of the key criteria for discharge of preterm infants from the hospital,\(^{2,11}\) there is no evidence to date that earlier transition to an open crib is associated with earlier discharge.

We evaluated the differences in transferring infants from an incubator to an open crib at a weight 200 g lower and at a postmenstrual age 1 week younger, compared with infants in the ST group. Despite this, they did not require a longer stay in the open crib and their LOS was significantly shorter. We estimated a difference between groups of 7 days in our sample size calculation, but the actual difference was even greater. There were no differences between the 2 groups with respect to temperature control after transfer. GV values were not different between groups during the time spent in the open crib and were in the range reported by Heimler et al.\(^{11}\) and Patel et al.\(^{12}\) Moreover, the group assignment did not affect caffeine use; caffeine administration was stopped 48 hours before expected weaning from the incubator for 22 infants in the ET group and 21 infants in the ST group. Our results showed that infants in the ET group were discharged earlier just because they were transferred earlier to an open crib. In fact, the time spent in an open crib was the same for the 2 groups. Infants in the ET group did not require more time to achieve full feeding competency, and the breastfeeding amount was similar to that in the ST group. Spending more time in the incubator might have implied some delay in suck-feeding competency of the ST group. Earlier discharge did not result...
in short-term adverse health outcomes or increased postdischarge healthcare utilization. One infant in the ST group needed to be rehospitalized 5 days after discharge because of a urinary tract infection, which caused severe feeding problems.

Profit et al6 and Altman et al16 highlighted existing variations in LOS and postmenstrual age at discharge in different regions of the United States and the United Kingdom and in Sweden, which might be based on differences in incubator weaning protocols. It is difficult to compare LOS and postmenstrual age at discharge reported in those studies with our results because our population included only infants with birth weights of <1600 g. Optimal criteria for weaning to an open crib are not standardized and often are based on prescriptive weights or postmenstrual ages. One report suggested that preterm infants can be weaned from an incubator at weights as low as 1500 g. Sutter et al17 showed that weaning at 1700 g was safe and effective only for prematurely born infants with birth weights of >1000 g. Medoff-Cooper18 studied 270 infants with a mean birth weight of 1188 g and a mean GA of 29.3 weeks, who were successfully moved to an open crib at a mean weight of 1598 g. West et al12 compared 4 cohorts of infants, who were transferred to an open crib at 1800 g, 1700 g, 1600 g, and 1500 g; the authors found no differences in transfer failure rates, weight gains, temperature control ability, weights, and postmenstrual ages at discharge. None of those studies reported results from randomized trials. Schneiderman et al19 recently conducted a retrospective study evaluating the relationships of incubator weaning at different weights with oral feeding, GV, and LOS for 2908 preterm infants in 579 hospitals throughout the United States. The median weight at the time of transfer to an open crib was 1830 g, and only 8.3% of the included infants were transferred at <1600 g. Interestingly, infants weaned at lower weights had a lower rate of failure and the highest overall GV from transfer to an open crib to discharge. Therefore, earlier transfer to an open crib may have a favorable impact on infant development, whereas delayed incubator weaning may have subsequent adverse effects on parental bonding.4 In addition, nurses caring for infants in open cribs may perceive the infants as being closer to discharge and therefore may increase discharge teaching for the parents.

One limitation of our study is that the sample size was calculated only on the basis of the primary outcome (LOS). For this reason, the study was not powered adequately to detect differences in secondary outcomes that occur infrequently, such as hospital readmission during the first week after discharge. Larger, adequately powered, randomized trials should address these issues. Moreover, this study was conducted in a subintensive ward, and only 1 of the patients in each group had a GA of <28 weeks at birth. With this limitation, our study demonstrated that weaning moderately preterm infants (GAs of 30–35 weeks at birth) from an incubator to an open crib at weights as low as 1600 g significantly reduced LOS without apparent adverse effects. Future trials should replicate the findings with more premature infants.

REFERENCES


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