How much does a minimum weight at discharge delay discharge from the neonatal intensive care unit?

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Article

Keywords:

Posted Date: September 30th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2076837/v1

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Abstract

Objective: Determine if discharge at physiologic maturity (PM) (based on national guidelines) even if <1800g, the minimum weight for discharge at our institution, will decrease hospital days (HD).

Methods: We reviewed 129 infants with birthweight 1300g-1800g. Data were analyzed by paired t-test/Wilcoxon-rank-sum test.

Results: Age at discharge vs. age at PM was 0.55d per infant higher (P-value 0.033) resulting in 71 total HD. For SGA babies, this difference was 1.47d vs 0.19d in non-SGA babies (P-value 0.0243) and this difference was an average of 2.63d (P-value <0.001) for those who reached PM <1800g, contributing to 50 of 71 HD potentially saved.

Conclusion: There was a 0.55-2.6-day difference between age at discharge and age at PM, greater in SGA infants and infants who reached PM prior to 1800g. There might be an opportunity to send infants home earlier to their families if there is no minimum weight required.

Introduction

Low birth weight (LBW) infants make up only 8% of total hospitalizations, and yet their care accounts for nearly half of hospitalization-related health care expenses in the first year of life. While cost per infant hospitalization is highest for extremely preterm infants, two-thirds of the total prematurity-related cost is due to patients born at greater than 28 weeks of gestational age (wga)\(^1\). In addition to cost, neonatal intensive Care Unit (NICU) hospitalization also decreases parent-infant bonding and increases the burden of psychological illnesses in NICU families with long-term consequences\(^2\,3\). While bonding with parents can be improved by empowering them to care for their babies in the neonatal intensive care unit (NICU), bonding with extended family may be more effective in the home environment. Limiting unnecessary additional hospitalized days may therefore alleviate cost burden and improve family-infant bonding\(^4\,5\). Prior studies have established the safety of earlier neonatal discharge, contingent on reaching physiologic maturity using a variety of criteria\(^4\,6\,7\,8\). Both the American Academy of Pediatrics (AAP) and the Canadian Pediatric Society guidelines recommend discharge at physiologic maturity rather than waiting for a specific weight threshold\(^9\,10\).

Our institution's current NICU policy recommends a minimum weight of 1800grams (g) in addition to other physiologic maturity criteria for discharge. When this policy was devised, the lowest weight that car seats could accommodate was 4 pounds (1800g); however, this policy has remained in force despite the emergence of commercially available car seats which can safely accommodate weight as low as 3 pounds (~1360g). In the previous studies that evaluated early discharge based on physiologic maturity, the average weight in the early discharge groups ranged from 1800g to 2000g, so the car seat was not the primary issue at that time\(^4\,8\). However, babies may achieve physiologic maturity well below 1800g\(^7\). We aimed to evaluate if there were a significant number of hospital days that could be avoided at our
institution if infants were discharged when they achieved physiologic maturity rather than remaining admitted until reaching the specific weight threshold of 1800g. We focused on small for gestational age (SGA) infants who may be physically and neurologically more mature at lower weights compared to non-SGA infants, so we expected that the length of stay for SGA infants may be disproportionately lengthened by a minimum weight discharge policy.

**Methods**

We performed a retrospective chart review to test the hypothesis that a clinically relevant number of hospital days, defined *a priori* and subjectively as at least 20 days annually for the population, could have been avoided if discharge occurred at physiologic maturity rather than awaiting the institutional policy specific discharge weight of 1800g. Each infant’s chart was reviewed to assess the day of life (DOL) and the postmenstrual age (PMA) when physiologic maturity was achieved. This was compared to the actual discharge DOL and PMA. Secondary outcomes included the effect of SGA status on hospital days saved, adverse events related to a potentially longer length of stay to gain weight of 1800g, and the effect of involvement of child protective service on the length of stay. We restricted our study population to infants with birthweight of 1300g to 1800g to target those who we thought would be most likely to be affected by this minimum weight policy. Physiologic maturity was defined using national criteria interpreted locally as meeting all the following milestones: 1) maintaining axillary temperature in an open crib of ≥ 36.3°C for at least 48 hours, 2) taking oral feed volume of at least 120 ml/kg/day, 3) gaining weight for two days consecutively without an enteric tube in place, 4) no apnea or bradycardia for 5 days or for 10 days after stopping caffeine, and 5) no desaturations for one day. Apnea was specified as no respirations for 15 seconds, bradycardia as heart rate below 100 in infants with PMA of less than 37.0 wga and less than 80 for infants with PMA ≥ 37.0 wga. Bradycardia events were not “counted” if occurring with oral feeding or regurgitation, unless requiring an intervention. Desaturation was documented if the infant had a pulse oximetry saturation of less than 90% while resting, but not if this occurred while orally feeding or during regurgitation, unless the event required intervention (i.e., suctioning, physical stimulation or change in position). Apnea, bradycardia, and desaturation definitions were derived from our unit’s current practice. DOL and PMA when an infant achieved each of these physiologic milestones were recorded. In addition, demographic information such as sex, gestational age at birth, birth weight, race, SGA, and other comorbid conditions were also recorded. Infants with significant congenital anomalies that could delay discharge were excluded from the study. All charts were reviewed by one person (RKD) for consistency. This study protocol was approved by the University Hospitals Institutional Review Board (STUDY 20200553).

*Sample size calculation:* To detect a difference of 20 hospitals days, 8 infants (each as his/her own control) were needed, based on a standard deviation of 17 days from a previous study, with alpha of 0.05 and power of 0.8. Given multiple assumptions and planned subgroup analyses, a larger sample from a full year cohort was included to ensure adequate power.
Data analysis: We used the paired t-test to analyze normally distributed continuous data, the Wilcoxon rank sum test for not normally distributed continuous data. Statistical analyses were conducted using STATA 15.1 (STATA Corporation, College Station, TX, USA).

Results

There were 143 infants discharged from our institution's NICU in 2019 with a birth weight of 1300g -1800g. Of these, 14 patients were excluded: four had missing information in their charts about when each physiologic maturity milestones were achieved and ten had congenital anomalies likely to significantly alter length of stay (LOS (Supplemental Figure)). Of the remaining 129 study patients, 36 (28%) were SGA infants. Mean gestational age of the study population was 32.4wga (Table 1). Seventy five percent of our infants were less than 34.0 wga at birth and overall average birthweight of cohort was 1593g. There was a higher predominance of females (55.5%) compared to males.

Thermoregulation was achieved at the lowest average PMA of 34.6 wga (Figure 1) (the earliest physiologic maturity milestone reached on average), followed by achieving a weight of 1800g at 34.7 wga, resolution of desaturation at 35.5 wga, resolution of apnea and bradycardia at 35.7 wga, adequate oral feeding at 35.8 wga, and, lastly, consistent weight gain at 36.6 wga. On average, infants achieved physiologic maturity 0.55 days earlier than when they were discharged, resulting in an estimated 71 excess hospital days for the entire cohort (Table 2). When SGA infants were compared with non-SGA infants, there was a significantly larger difference between DOL and PMA at physiologic maturity compared with actual discharge. For SGA infants, this difference was 1.5 days compared to non-SGA for whom the difference was 0.2 days with p-value of 0.02 (Table 3). Unexpectedly, SGA infants reached physiologic maturity on average at 37.4 wga, a whole week later than non-SGA infants who achieved equivalent milestone on average at 36.4 wga. Accordingly, actual discharge for SGA infants also occurred significantly later at an average of 37.6 wga, compared to 36.4 wga for non-SGA infants.

The difference between physiologic maturity and actual discharge was most notable in the 19 infants who reached physiologic maturity prior to 1800g with an average of 2.6 days per infant (P-Value < 0.01), contributing to 50 of the 71 potentially excess hospital days. Upon further evaluation of these 19 infants who reached physiologic maturity prior to 1800g, the difference in physiologic maturity and actual discharge was 7 days or more for 3 infants (Figure 2). The lowest weight at which an infant achieved physiologic maturity was 1545g. Additionally, when these 19 infants’ charts were reviewed in more detail, nine charts included mention of awaiting weight gain to 1800g as a specific reason for holding discharge. There was no adverse event documented in infants who awaited discharge to gain weight of 1800g. Out of 129 infants, ten infants had child protective services (CPS) involvement and there was no significant effect noted on involvement of CPS on length of stay.

Discussion
The American and Canadian guidelines recommend discharge of premature infants when they reach physiologic maturity rather than requiring attainment of a specific weight\(^9,10\). Our NICU’s discharge policy mandates achieving a specific weight threshold of 1800g in addition to meeting physiologic maturity criteria prior to hospital discharge. Anecdotally, some other institutions also use a specific discharge weight criterion of 1800g because the lowest weight that most car seats can accommodate is 4 pounds (1800g). However, with the recent availability of car seats that can accommodate weight as low as 3lb (1360g), this requirement of minimum weight at discharge could be reconsidered.

In our cohort, infants achieved physiologic maturity approximately half a day earlier than actual discharge for a total of 71 days across 129 babies. While this may seem inconsequential on an individual basis, the aggregate across families and hospital systems using a weight-based discharge policy certainly is meaningful. Additionally, the difference in the length of stay was particularly exaggerated for SGA infants and infants who achieved physiologic maturity prior to reaching 1800g. Nineteen infants who achieved physiologic maturity prior to 1800g were only ~15% of the population, however contributed to 65% (50/71 days) of the hospital days saved. Some of these infants could have been discharged as much as a week earlier if discharged based on physiologic maturity alone rather than the additional minimum weight criteria; 12 of these 19 infants were SGA.

Our findings are consistent with the randomized controlled trial done by Cruz et al. who evaluated length of stay and adverse events in an early discharge group who were meeting physiologic maturity between 1300g to 1350g compared to infants discharged at a specific weight of 1800g per their hospital policy. They noted that majority of the infants who were meeting physiologic maturity criteria at lower weight were SGA infants. SGA infants may be more mature at a given weight compared to appropriate for gestational age (AGA) infants because of their higher gestational age for a given weight. In our study, an unexpected finding was that SGA infants reached physiologic maturity at one-week later PMA compared to non-SGA infants. This has not been described in the literature to our knowledge and should be validated in other cohorts. One possible explanation for our finding could be that there were some infants with inaccurate gestational age dating. We have no reason to believe our assigned GAs are not accurate; these were based on “best obstetrical dating” and our general practice is to do a Ballard exam if this is felt to be inaccurate at the time of admission. However, we did not check carefully for this study whether a first trimester ultrasound was obtained to confirm dating. However, if anything, with a later in gestation ultrasound for those without first trimester dating, a smaller size infant could be falsely thought to be less mature, so making it appear that they are achieving milestones at a younger GA, not higher. We aim to identify which physiologic maturity criteria was achieved later in the SGA group compared to non-SGA group in our study population, however this needs to be replicated in another study with infants who have more formally documented first trimester dating.

Due to the retrospective nature of the study, the difference in discharge at physiologic maturity and actual discharge cannot be attributed specifically to the minimum weight policy alone and delays in discharge could have been due to transportation, or other circumstances not specifically mentioned in the chart. However, it is important to note that nine out of nineteen infants who reached physiologic maturity prior
to 1800g had medical record notation of explicit mention of awaiting weight gain as a sole reason for holding discharge. And there is no reason to think that these other delays would be overrepresented in the smaller size babies, although we did not measure this. Our study was not designed to assess the safety of early discharge; however, safety of discharge regardless of weight has been studied in randomized control trials in which they found no adverse events related to early discharge of infants who otherwise met physiologic maturity criteria\textsuperscript{4,7,8}. Notably, our study population was limited to patients with birth weights of 1300g to 1800g; there could have been more hospital days saved if the study population were broader. We selected patients of 1300g to 1800g because we thought this was the population most likely to be affected by the minimum weight policy. Additional studies could include babies of lower birthweight.

With a daily hospital room charge of $7850 before insurance is applied, as much as $557,350 could have been saved by this cohort if qualified infants were discharged at time of physiologic maturity. Previous randomized controlled trials have also found that early discharge at physiologic maturity, even with the cost of close follow up programs, can be cost effective\textsuperscript{4,7,8} . In 1986, Brooten et al. found that if low birth weight infants were discharged when they reached physiologic maturity, $162 million dollars can be saved annually nationwide even after accounting for cost of follow up programs that include home visitation by nurses. In summary, there may be an opportunity to curtail cost related to hospitalization with early discharge in NICUs that still use weight-based criteria for discharge.

**Conclusion**

In a cohort of 129 infants 1300-1800g at birth, on average an infant achieved physiologic maturity 0.55 days earlier than their actual discharge, possibly saving 71 hospital days overall. The difference between discharge at physiologic maturity and actual discharge was greater in infants who were SGA (1.5 days) and those who achieved physiologic maturity at a weight of <1800g (2.5 days), our minimum weight for discharge. At NICUs with a weight-based discharge policy, there may be an opportunity to discharge infants to their families sooner by using physiology-based criteria rather than weight-based discharge criteria.

**Declarations**

**Competing Interests:** The authors declare no competing interests.

**Funding:** The first author received a Fellowship Research Award Program (FRAP) grant through University Hospitals Rainbow Babies and Children's Hospital.

**Author's Contribution:** Conceptualization: RD, RMR; Methodology: RD, RMR, SR and MB; data curation: RD; quantitative analysis: RMR, RD; writing -original draft preparation: RD; writing – review and editing: RD, MB, SR, RMR. All authors approved the final version of the article.
References


Tables

Table 1: Study Population Demographic
### Table 2: Hospital days saved

<table>
<thead>
<tr>
<th></th>
<th>Difference in days of PM* and Discharge per baby</th>
<th>Total # hospital days saved in one year for babies with birth weight 1300-1800g</th>
</tr>
</thead>
<tbody>
<tr>
<td>All babies (n=129)</td>
<td>0.55</td>
<td>71 days total</td>
</tr>
<tr>
<td>SGA babies (n=36)</td>
<td>1.47</td>
<td>53 days total</td>
</tr>
<tr>
<td>Babies who reached PM</td>
<td>2.63</td>
<td>50 days total</td>
</tr>
<tr>
<td>before weighing 1800g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 19**)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*PM – Physiologic Maturity, **12/19 were SGA

### Table 3: SGA Versus Non-SGA
<table>
<thead>
<tr>
<th></th>
<th>SGA</th>
<th>NON-SGA</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gestational Age</strong></td>
<td>34.9 (1.3)</td>
<td>31.4 (1.6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Birth Weight</strong></td>
<td>1586 (133)</td>
<td>1609 (106)</td>
<td>0.35 (NS)</td>
</tr>
<tr>
<td><strong>DOLPM, (days)</strong></td>
<td>17.1 (9.0)</td>
<td>34.8 (17.9)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>DOLdc</strong></td>
<td>18.6 (8.2)</td>
<td>35.0 (18.1)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>DOLdiff:</strong></td>
<td>1.5 (3.0)</td>
<td>0.19 (2.79)</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>(DOLdc-DOLPM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PMAPM (wks)</strong></td>
<td>37.4 (2.08)</td>
<td>36.4 (1.57)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>PMAdc</strong></td>
<td>37.6 (1.56)</td>
<td>36.4 (1.4)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>PMAdiff:</strong></td>
<td>0.2 (0.44)</td>
<td>0.031 (0.40)</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>(PMAdc-PMAPM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight at dc</strong></td>
<td>1982 g (223)</td>
<td>2339 (559)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Data are presented as mean (SD)

SGA, small for gestational age, PM, physiologic maturity, dc, discharge, DOL, day of life, PMA – postmenstrual age, diff, difference

*SGA vs. non-SGA, by paired t-test

**Figures**
Figure 1

Average PMA along with with range when infants achieved physiologic maturity milestones. Individual physiologic maturity (PM) milestones were reached on average between 34.6 weeks to 36.0 weeks PMA. All milestones were reached at an average PMA of 36.6 weeks, close to the actual discharge of 36.7 weeks in this one-year cohort of 129 babies born at 1300-1800g.

PMA—postmenstrual age, Thermoeglation – Maintaining temperature in an open crib of ≥36.3°C for 48 hours, Wt of 1800g – when infant reaches 1800grams, Desaturation – no desaturations for 1d, Apnea/Brady – no apneas/bradycardias for 5d, Oral/Bottle feed – oral feed volume of ≥120 ml/kg/day, Wt gain – consistent weight gain for 2 days on oral feeds, PM – when infant meets all 5 milestones of physiologic maturity and could be discharged, DC – when infant was actually discharged (note legend reads across in order)
Figure 2

Infants who reached physiologic maturity prior to 1800g. Horizontal axis represents the difference in the number of days between when infants reached PM and actual discharge. Vertical axis on left depicts the number of infants with those specific difference in days between PM and actual discharge. Vertical axis on right with numbers along line on graph depicts the average weight of infants at those days difference between PM and actual discharge.

*PM – Physiologic Maturity

** DOL – Day of Life

Supplementary Files

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- SupplementalFigure.docx