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Original Research

Neonatal intensive care unit discharge of infants with cardiorespiratory events: Tri-country comparison of academic centers

C. Carlos[a,b,*], J. Hageman[a,c], M. Pellerite[a,b], B. McEntire[d], A. Côté[e], A. Raoux[f], P. Franco[f], C. Rusciolelli[c], L. Consenstein[g] and D. Kelly[h]
[a]*University of Chicago, Chicago, IL, USA*
[b]*Department of Pediatrics, Comer Children's Hospital, Chicago, IL, USA*
[c]*Department of Pediatrics, NorthShore University Health System, Evanston, IL, USA*
[d]*American SIDS Institute, Naples, FL, USA*
[e]*Division of Pediatric Pulmonology, Montreal Children's Hospital, Montreal, QC, Canada*
[f]*Pediatric Sleep Unit, Service Epilepsie, Sommeil, Explorations Fonctionnelles Neuropediatriques, Hôpital Femme Mère Enfant, University Lyon, Lyon, France*
[g]*Department of Pediatrics, St. Joseph Hospital, Syracuse, NY, USA*
[h]*Department of Pediatrics, Holyoke Medical Center, Mount Holyoke, MA, USA*

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Abstract.
OBJECTIVE: Compare how NICUs within academic centers in Canada, France, and the United States make discharge decisions regarding cardiorespiratory recordings and home use of apnea monitors, oximeters and caffeine.
STUDY DESIGN: An anonymous survey was sent to neonatologists through the member listserv of the American Academy of Pediatrics Section on Perinatal Pediatrics, the Canadian Fellowship Program Directory, and to Level 3 NICUs in France.
RESULTS: The response rates were 89%, 83%, and 79% for US, Canada and France respectively. In Canada, 45% perform pre-discharge recordings vs. 38% in France and 24% in the US. Apnea free days prior to discharge were required in 100% of centers in Canada, 96% in France, and 92% in the US. In Canada and France, 65% and 68% of units discharge patients on monitors vs. 99% in the US. 64% of the US centers sometimes use home caffeine compared to 40% in Canada and 34% in France. Over 60% of the centers in Canada and France wait until at least 40 weeks post menstrual age to discharge patients, whereas only about 33% of the US wait that late to discharge patients.
CONCLUSIONS: Discharge practices from NICUs are not well standardized across institutions or countries. Canada and France keep infants in the hospital longer and are less likely than the US to use home monitoring and home caffeine.

Keywords: Neonatal intensive care unit discharge, neonatal discharge, cardiorespiratory events

*Corresponding author: Dr. Christine Carlos, Comer Children's Hospital, University of Chicago, 5721S. Maryland Ave, Chicago, IL 60637, USA. Tel.: +1 773 702 6435; Fax: +1 773 834 0748; E-mail: Christine.carlos@uchospitals.edu.

1. Introduction

Neonatal intensive care unit (NICU) and special nursery admissions occur in 7–14% of all births [1, 2]. The gestational age of infants admitted spans from 23 weeks to post term gestation of greater than 42 weeks [1]. The average length of stay for an infant in the NICU ranges from a few days to several months.

The discharge of infants from the NICU is a complex process that requires forethought and planning. This can be the direct result of the patients themselves, coordination of care after a prolonged hospital stay, and resolution and/or improvement of complex multifactorial medical diagnoses. The risk assessment for hospital readmission and death within the first year following discharge remains a concern [3].

Taking this into account, additional factors to be considered are a family's readiness for discharge and completion of necessary education and training. Families often need additional supports such as home equipment and technological support. Appropriate multidisciplinary follow-up should also be arranged prior to discharge [4–7].

The true cornerstone of the discharge decision is the readiness of the infant. The neonatal period is characterized by physiologic changes greatly influenced by gestational age and confounding illnesses and complications. Respiratory difficulties remain one of the greatest challenges, apnea being a common problem. The widely accepted definition of apnea in infants is a cessation of breathing for greater than or equal to 20 seconds, or a shorter respiratory pause associated with oxygen desaturation and or bradycardia [8]. While the broad general consensus of NICU discharge is based on medical stability and physiologic readiness of infants, the parameters by which these are measured is more controversial.

The purpose of this survey is to characterize and compare the NICU discharge practice of infants with cardiorespiratory events in the United States, Canada and France.

2. Methods

2.1. Study design

An anonymous 28 question online survey was sent in August 2009 to neonatologists using www.surveymonkey.com through the member listserv of the American Academy of Pediatrics Section on Perinatal Pediatrics (coordinated by JC and JH), the Canadian Neonatal Fellowship Program Directory (coordinated by AC), and to Level III NICUs in France (coordinated by AR and PF). The survey included multiple choice, open-ended questions, and clinical vignettes regarding institutional demographics and specific discharge practices including the utilization of pre-discharge cardiorespiratory recording, home apnea monitors and pulse oximeters, the use of caffeine after discharge, and postmenstrual age (PMA) at discharge. For the purpose of this study, apneas, bradycardias, and desaturations were either listed as a group representing the accepted definition of apnea in infants or addressed as cardiorespiratory events. Clinical vignettes included pertinent information such as gestational age, PMA, and birth weight.

2.2. Data analysis

In order to eliminate bias of unequal numbers of respondents from each institution, we limited primary analysis to the first response from each institution. The first response was matched to its corresponding city and fellowship program in the United States and Canada. A comparison analysis was completed and statistical analysis was performed utilizing the student t test. Data were expressed as percentages and the mean $\pm$ SD. Statistical significance was $p < 0.05$.

3. Results

Responses were obtained from neonatologists at 100 of 112 (89%) US NICUs with fellowship programs (USFPs), 20 of 24 (83%) Canadian NICUs with fellowship programs (CFPs), and 56 of 71 (79%) Level III NICUs in France (FRL3s).

Pre-discharge cardiorespiratory recordings, continuous or event recording, was utilized at 24 of 100 (24%) US sites, 9 of 20 (45%) Canadian sites, and 21 of 56 (38%) of French sites (Fig. 1). Potential cardiorespiratory recording parameters were respiratory movements (chest impedance), nasal airflow (capnography), EKG, esophageal pH probe, or sleep staging. In over 90% of the NICUs surveyed, infants were required to be free of apnea for a period of days before discharge. Of Canadian NICUs included, 20 of 20 (100%) required a number of apnea free days. Likewise, 92 of 100 (92%) of US NICUs and 54 of 56

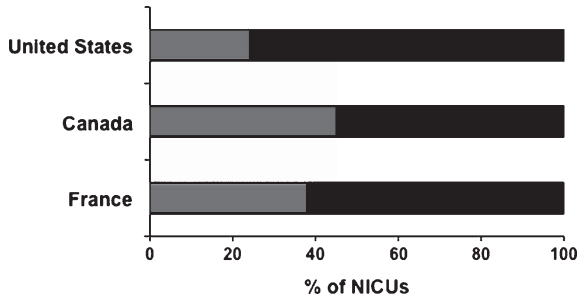

Fig. 1. Percentage of surveyed NICUs by country that do and do not use predischarge cardiorespiratory recording (CR). ■ Do perform predischarge CR; ■ Do not perform predischarge CR.

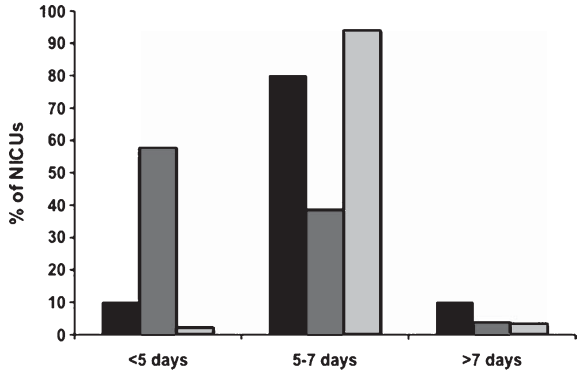

Fig. 2. Percentage of NICUs by country that require <5, 5–7, and >7 apnea free days prior to discharge. ■ Canada; ■ France; □ United States.

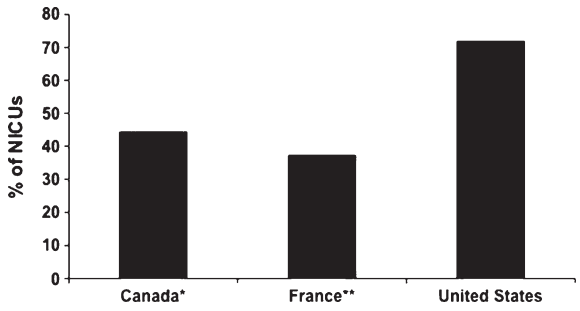

Fig. 3. Percentage of NICUs by country that do and do not discharge infants home on caffeine. US compared to Canada (*p-value 0.03) and US compared to France (**p-value 0.001). ■ Discharge > or = 1 infant per year on caffeine.

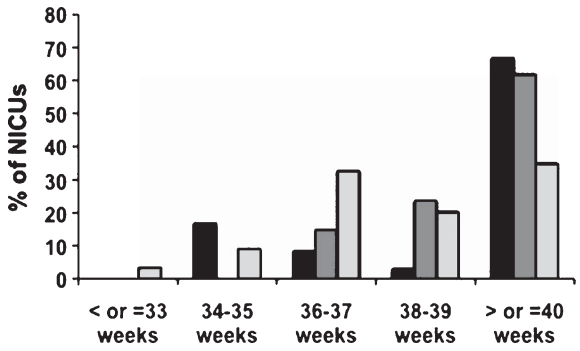

Fig. 4. Percentage of NICUs by country that discharge infants at < or = 33 weeks, 34-35 weeks, 36-37 weeks, 38-39 weeks, and > or = 40 weeks post menstrual age. ■ Canada; ■France; □United States.

(96%) French NICUs also require apnea free days prior to discharge.

The number of required apnea free days prior to discharge was somewhat variable among institutions and countries. A total of 2 of 20 (10%) and 2 of 100 (2%) respondents surveyed in Canadian and US NICUs, respectively, discharge infants with less than 5 apnea free days. This is in contrast to 30 of 56 (54%) French NICUs surveyed. In Canada, 5–7 apnea free days were required in 17 of 20 (85%) NICUs, in the US 84 of 100 (84%), and in France 20 of 56 (36%). Greater than 7 apnea free days were required in 2 of 20 (10%) Canadian centers, 3 of 100 (3%) US centers, and 2 of 56 (4%) French centers (Fig. 2).

Similarly, it is commonplace to administer caffeine to reduce the frequency of apnea of prematurity in hospitalized infants. However, discharge of infants on caffeine is less frequent. Neonatologists were asked how many infants are discharged on caffeine per year and responses were divided into institutions that do discharge on caffeine and units that do not. This was statistically significant with a notably higher percentage in the US (70%) discharging some infants home on caffeine compared to Canada (44%, p value = 0.03) and France (37%, p value <0.001) (Fig. 3).

With regard to home surveillance after discharge, home apnea monitoring and pulse oximeters have been available for a number of years. Neonatologists were asked how often infants were discharged with either type of monitor. The responses were used to distinguish whether institutions ever discharge infants home with monitors. In Canadian and French NICUs, 13 of 20 (65%) and 38 of 56 (68%), respectively, will discharge patients on home apnea monitors. This is in contrast to 99 of 100 (99%) of US NICUs who will discharge infants on home apnea monitors.

Finally, in response to a vignette asking at what post menstrual age would an infant be most likely to be discharged if they were otherwise ready except

for persistent cardiorespiratory events not requiring stimulation, 8 of 12 (67%) Canadian centers, 31 of 89 (35%) US centers, and 21 of 34 (62%) French centers would discharge at post menstrual age greater than or equal to 40 weeks (Fig. 4).

4. Discussion

We surveyed neonatologists in Canada and the United States practicing at centers with fellowship programs as well as neonatologists practicing at Level III NICUs in France regarding discharge practices of infants with cardiorespiratory events and the approach to the infant discharge process. It was our hope that the data would provide insight into common discharge practices and better delineate a model of current practice. We observed a wide variation of practices both within countries and among countries. This could be due to a lack of clear standard of care after discharge where home monitors and caffeine are concerned.

In our sample, less than half of participating neonatologists require cardiorespiratory recording prior to discharge. Use was most robust in Canada, followed by France, and then the United States. Despite this, almost all NICUs did require a period of apnea free days prior to discharge emphasizing the obvious importance of cardiorespiratory stability before discharge.

Interestingly, the number of apnea free days required prior to discharge was similar in Canada and the US with the majority requiring 5 to 7 days. This is also consistent with previous studies [9]. It is worth noting that within this grouping a greater proportion of Canadian units required 7 days, the higher end of the range, whereas a greater proportion of US units required 5 days, the lower end of the range. Most notably, however, was that overall the majority of centers in France require less than 5 apnea free days. This accounts for 10% or less of centers in Canada and the US thereby making France the least conservative in this discharge practice.

Previous studies have identified methylxanthines, theophylline and caffeine specifically, as effective treatments for apnea of prematurity. Methylxanthines block inhibitory adenosine receptors leading to stimulation of neural respiratory mechanisms thereby decreasing the incidence of apnea. Caffeine is preferred for its longer half-life and larger safety margin and has remained a mainstay of inpatient treatment and prophylaxis of apnea of prematurity [10–13]. However, discharging infants home on caffeine appears less agreed upon. Discontinuation of caffeine usually occurs between 32–34 weeks postmenstrual age based on the natural course of apnea of prematurity. Among the three groups included in our study, on average, approximately half of NICUs will discharge infants home with the prescription of caffeine. This was the one practice that showed a statistically significant difference among all three countries with more US centers discharging infants home on caffeine. One limitation of this study is that there are no follow-up data such as length of treatment after discharge and rate of complications.

Relatedly, discharging infants with home monitoring, apnea or pulse oximetry also lacks consensus [12]. Current literature suggests that acute cardiorespiratory events can occur well after the full term postmenstrual age is achieved, especially in infants born premature [14, 15]. Canada and France appear to have similar practices in that one third of NICUs surveyed will never discharge infants home with monitors compared to almost all US respondents that will. As will be seen later, the Canadian and French centers discharge infants home at a later post menstrual age and this might influence the practices about home monitoring.

A vignette was used to assess the post menstrual age at which NICUs would discharge otherwise ready infants except for cardiorespiratory events not requiring stimulation. Cardiorespiratory events not requiring stimulation refers to desaturations, apneas, bradycardias that infants are able to recover from without external intervention such as bag-mask-valve, stimulation, or escalation of respiratory support. Responses showed that Canada and France are more likely to discharge at postmenstrual ages of 40 weeks or greater. In contrast, US centers were more evenly stratified with some centers discharging infants as early as 36 weeks or as late as 40 weeks or greater.

This study is not without its limitations. The sample size and number of respondents is small and limited by the number of Canadian and US NICUs with neonatology fellowships as well as the number of Level III NICUs in France. These groups were chosen on the assumption of a higher acuity of care. Despite being limited by number of institutions, the response rate from all 3 groups surveyed was encouraging.

A second limitation is that only the first responses from each institution were used. As demonstrated by the survey, discharge practices and internal discharge decision-making varies widely from institution to insti-

tution and country to country. This trend most likely also extends to provider differences within a single institution thereby creating an influence of physician bias to our collected data.

Thirdly, this survey did require the use of theoretical questions and vignettes in an attempt to assess and gather information regarding discharge decisions which is less concrete than actual patient discharge data. However, it does provide some insight into the individual physician's thought process when contemplating discharge and discharge planning.

Finally, it may be observed that there were no post discharge or outcome data collected or reported. While ultimately this would be helpful in creating a model of best practice for discharge from NICUs, our initial aim was to first outline the current practices.

In conclusion, we performed a survey of high acuity NICUs in the United States, Canada, and France in an attempt to identify a consensus of current discharge practices of infants. Trends show a minority of NICUs using cardiorespiratory recording amongst all three countries but an overwhelming majority that require a period of apnea free days. The majority of institutions will allow discharge of infants on home apnea monitors and/or pulse oximeters. A majority of US centers will occasionally discharge infants home on caffeine in contrast to a majority of Canadian and French centers where infants are not discharged on caffeine. US centers also tend to discharge infants at earlier post menstrual ages compared to infants in Canada and France. While this survey was able to identify some trends, NICU discharge practices continue to vary institution to institution.

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Disclosure statements

The authors have no conflict of interest or financial relationships relevant to this article to disclose.

References

[1] Osterman MJK, Martin JA, Mathews MS, Hamilton BE. Expanded data from the new birth certificate, 2008. National Vital Statistics Reports 2011;59(7):1-29.
[2] National Perinatal Information Center/Quality Analytic Services and March of Dimes. Special Care Nursery Admissions. 2011 Oct. Cited 2014 Jul 07. Available from: http://www.marchofdimes.org/peristats/pdfdocs/nicu_summary_final.pdf
[3] Escobar GJ, Joffe S, Gardner MN, Armstrong MA, Folck BF, Carpenter DM. Rehospitalization in the first two weeks after discharge from the NICU. Pediatrics 1999;104:e2.
[4] American Academy of Pediatrics, Committee on Fetus and Newborn. Hospital Discharge of the High-risk Neonate. Pediatrics 2008;122(5):1119-26.
[5] Merrit T, Pillers D, Prows S. Early NICU discharge of very low birth weight infants: A critical review and analysis. Semi Neonatol 2003;8(2):95-115.
[6] Brooten D, Kumar S, Brown LP, Butts P, Finkler SA, Bakewell-Sachs S, et al. A randomized clinical trial of early hospital discharge and home follow-up of very low birth weight infants. N Engl J Med 1986;315(15):934-9.
[7] Andrews B, Myers P, Osterhout P, Pellerite M, Zimmerman A, Msall M. NICU Follow-up: The developmental and advocacy perspectives. Neoreviews 2014;15(8):e33.
[8] Committee on Fetus and Newborn. American Academy of Pediatrics. Apnea, sudden infant death syndrome, and home monitoring. Pediatrics 2003;111(4):914-7.
[9] Darnall RA, Kattwinkel J, Nattie C, Robinson M. Margin of safety for discharge after apnea in preterm infants. Pediatrics 1997;100(5):795-801.
[10] Henderson-Smart DJ, De Paoli AG. Methylxanthine treatment for apnoea in preterm infants. Cochrane Database Syst. Rev 2010;12:CD000140.
[11] Schmidt B, Roberts R, Davis P, et al. Caffeine therapy for apnea of prematurity. N Engl J Med 2006;354(20):2112-21.
[12] Abu Jawdeh EG, O'Riordan M, Limrungsikul A, Bandyopadhyay A, Argus BM, Nakad PE, et al. Methylxanthine use for apnea of prematurity among an international cohort of neonatologists. J Neonatal Perinatal Med 2013;6(3):251-65.
[13] Rhein LM, Dobson NR, Darnall RA, Corwin MJ, Heeren TC, Poets CF, et al. Effects of caffeine on intermittent hypoxia in infants born prematurely. JAMA Pediatr 2014;168(3):250-7.
[14] Naulaers G, Daniels H, Allegaert K, Rayyan M, Debeer A, Devlieger H. Cardiorespiratory events recorded on home monitors: The effect of prematurity on later serious events. Acta Paediatr 2007;96(2):195-8.
[15] Eichenwald EC, Aina A, Stark AR. Apnea frequently persists beyond term gestation in infants delivered at 24-28 weeks. Pediatrics 1997;100:345-59.