Journal of Neonatal Nursing 25 (2019) 160–165

Contents lists available at ScienceDirect

Journal of Neonatal Nursing

journal homepage: www.elsevier.com/locate/jnn

Review

PART 2: Practice and research recommendations for quality developmental care in the NICU

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ARTICLE INFO

Keywords:
Preterm infant
Developmental care
Narrative overview
Interventions
Neonatal intensive care unit
Recommendations for practice
Recommendations for research

ABSTRACT

Developmental care interventions, which may promote preterm infant's neurodevelopment during the hospitalization in the Neonatal Intensive Care Unit, should be implemented and integrated to care delivered by nurses, other healthcare professionals, and parents. These interventions may have an impact on the preterm infants' developing brain and optimize their short and long-term health outcomes. Based on a previous narrative overview, more high-quality research is still needed in this field. Nevertheless, best practice of developmental care can still be recommended to improve today's neonatal clinical practice. The aim of this article is to provide both practice and research recommendations according to the seven categories of developmental care interventions in the neonatal intensive care unit: family-centered care, sleep protection, assessment and management of pain, infant positioning, optimized infant-driven feeding, administration of human milk, and control of the environmental light and noise.

1. Introduction

Developmental care (DC) encompasses a variety of interventions that may promote preterm infant's neurodevelopment during their hospitalization in the Neonatal Intensive Care Unit (NICU) (Kenner and McGrath, 2010; Symington and Pinelli, 2006). Whether they are delivered by parents (Nelson and Bedford, 2016), nurses or other healthcare professionals, these interventions should be implemented and integrated to care delivered in the NICU (Milette et al., 2017) because they have the potential to influence the preterm infants' developing brain and optimize short and long-term health outcomes (Altimier and Philips, 2013). For example, a multicenter longitudinal study outlined that higher levels of DC in the NICU were associated, in very preterm infants (i.e. ≤ 29 weeks of gestational age), to enhanced neurobehavior at term equivalent age (Montirosso et al., 2012). These findings align with work on the Neonatal Individualized Developmental Care Program (NIDCAP) where various studies showed positive effects on preterm infant's neurodevelopment (Als et al., 1994, 2003, 2004). Yet, according to findings related to the different DC interventions presented in a previous narrative overview (Lavallée et al., 2019), more larger-scale, high quality research is still needed in the field of DC to evaluate their effects on preterm infants' short and long-term health outcomes as well as their neurodevelopment in the NICU. This conclusion was also shared by Symington and Pinelli (2006) more than a decade ago following a systematic review looking at the effectiveness of DC interventions on various outcomes. Nevertheless, in light of research results previously published (Lavallée et al., 2019), best practices of DC can still be recommended to improve today's NICU clinical practice. The aim of this article is to provide both practice and research recommendations regarding implementation of DC in the NICU.

2. Methods

Practice and research recommendations that are presented in this article are based on a thorough literature review presented in a previous publication (Lavallée et al., 2019). Types of papers on which

DOI of original article: https://doi.org/10.1016/j.jnn.2018.08.008
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https://doi.org/10.1016/j.jnn.2019.03.008
Received 1 November 2018; Received in revised form 8 March 2019; Accepted 9 March 2019
Available online 26 March 2019
1355-1841/

Table 1
Main recommendations for practice.

Family-centered care	• Parents should be encouraged to participate in their infant's care and decision making, throughout the hospitalization; • Good communication is central to family-centered care implementation; • Parents are more involved in their infant's care when they are welcomed 24-hr at bedside (Family-friendly NICUs); • Consider parent's needs and put forward policies and amenities for parents to be able to integrate the healthcare team.
Sleep protection	• Provide individualized cue-based care (based on the preterm infant's behaviors and physiological stability); • Healthcare professionals should learn to interpret the infant's sleep-wake cycles and teach them to the parents; • Coordinate interventions accordingly (clustering care); • Positioning, light, noise and handling should be appropriate to protect preterm infants' sleep.
Assessing and managing pain	• Pain scores should be systematically evaluated, for each painful procedure, using a validated pain scale; • Combining various pain management interventions such as sucrose and non-nutritive sucking; • Engaging and involving parents in pain management (skin-to-skin contact).
Infant positioning	• Adapt the positioning to the preterm infant's needs; • Alternate the positions to prevent head asymmetries; • Infants < 37 weeks of gestational age should be in a position that recreates the fetal positioning; • Always monitor infants that are positioned in prone or side-lying; • Educate parents about the appropriate positioning for their infant.
Optimized infant-driven feeding	• Provide informational, practical and emotional support to parents to promote, establish and maintain breastfeeding in the NICU; • Encourage early, continuous and prolonged skin-to-skin contact to promote breastfeeding.
Administration of human milk	• Parents should be informed about pasteurized donor human milk which is the best alternative to the mother's milk.
Control of environmental light and noise	• Units with single-patient rooms are recommended for a better control of both light and noise levels; • Ambient noise level: 45 dB A per hour, should not exceed 50 dB A more than 10% of the time, always < 65 dB A; • Infants < 28 weeks of gestational age: < 20 lux; • Infant > 28 weeks of gestational age: cycled lighting, 200–225 lux the day and 20 lux for evenings and nights.

recommendations are based include primary research articles (n = 32), meta-analysis and systematic reviews (n = 19), review articles (n = 8), conceptual models (n = 3), policy statements (n = 2) and clinical guidelines (n = 7). A summary of the main recommendations for practice can be found in Table 1.

2.1. Recommendations for family-centered care

Family-centered care (FCC) has been identified as an overarching DC which seems to be addressed in the literature as a unique DC intervention but also through the seven other DC. Based on a systematic review of very low to moderate levels of evidence, core recommendations for FCC are based on five principals: family presence in the NICU, family support, communication with family members, use of various consultants, in addition to consideration of operational and environmental issues (Davidson et al., 2017). Parents have a central role in the NICU and should be encouraged by healthcare professionals to participate in their infant's care and decision making, throughout the hospitalization (Craig et al., 2015; Gooding et al., 2011). As per the Family Integrated Care (FICare) program, families should be cared for along with the preterm infant, in the NICU (Lee and O'Brien, 2018). It is also essential for parents to feel respected and dignified (Hill et al., 2018). To do so, good communication between healthcare professionals and families is central to FCC implementation (Hill et al., 2018). Families need clear, unbiased, complete and useful information, in order to participate to their infant's care decision making (Cocroft, 2012). Family's opinions and suggestions should be taken into account when elaborating care plans and services (Cocroft, 2012). In family-friendly NICUs, where parents are welcomed 24-hr at bedside, parents are more involved in their infant's care (Craig et al., 2015; Wigert et al., 2010), which has shown shorter hospital stays and less morbidity (Ortenstrand et al., 2010). Therefore, NICUs should consider parent's needs and put forward policies and amenities for them to be able to integrate the healthcare team (Gooding et al., 2011). Finally, the transition from the NICU to home should be initiated from the admission in the NICU by providing to parents opportunities to develop their caregiving competencies and discharge education (Craig et al., 2015). FCC also encompasses support and education for healthcare professionals (Bracht et al., 2013; Davidson et al., 2017).

Although the FICare program which encompasses FCC has shown beneficial effects on exclusive breastfeeding at discharge, weight gain and parental stress and anxiety, more large scale, multicenter RCTs are needed to better understand the effects of FCC on short and long-term preterm infant's health outcomes (O'Brien et al., 2013; O'Brien et al., 2018).

2.2. Recommendations for sleep protection

To protect preterm infants' sleep, empirical data show that providing individualized cue-based care, that being care delivered based on the preterm infant's behaviors and physiological stability throughout care delivery, can provide longer sleep periods (Calciolari and Montirosso, 2011). To do so, NICU healthcare professionals should learn to interpret the infant's sleep-wake cycles and coordinate interventions accordingly (Calciolari and Montirosso, 2011). A complete sleep-wake cycle includes wakefulness behaviors and sleep behaviors such as crying, active alertness, alertness, drowsiness, light sleep and deep sleep (Vandenberg, 2007). Care should be delivered when the infant shows alert behaviors, such as being quiet, showing low or a minimum of activity and having a focused attention, in order to minimize infant stress (Vandenberg, 2007). Moreover, healthcare professionals should allow a 90-min period without manipulation, after handling, in order to create opportunities for sleep cycles (Calciolari and Montirosso, 2011). Parents can be central partners able to participate in the recognition of their infant's sleep and awake cycles for care planning and interactions (Calciolari and Montirosso, 2011; Shields et al., 2012). Likewise, preterm infants' positioning in their incubator has also been linked to sleep protection in the NICU (Jarus et al., 2011; Peng et al., 2014a). Finally, for sleep protection, light, noise and handling should always be controlled and appropriate to the preterm infant's age and developmental status (Calciolari and Montirosso, 2011).

However, little research has been done in relation to interventions protecting preterm infants' sleep in the NICU with interventions such as clustered care. In fact, Holsti et al. (2005) have raised questions about the actual impact of clustering care, since it may be that the increase in sleep following the latter is caused by a larger energy expenditure during care. Valizadeh et al. (2014) conducted a crossover clinical trial to evaluate the effects of three clustered non-invasive procedures, such as taking the axillary temperature, changing the location of the pulse oximeter probe and changing the infant's position, compared to four non-invasive procedures, such as the three previously mentioned procedures added to gavage feeding, on the physiological responses of preterm infants. Valizadeh et al. (2014) found no difference in heart

rates before, during and after care, in the infants who received three clustered care interventions compared to infant who received four clustered care interventions. There was, however, a significant increase in heart when comparing before, during and after the clustered care procedures in these infants, yet the mean heart rates always remained within normal range. For this reason, Valizadeh et al. (2014) recommend clustering care for preterm infants of at least 32 weeks of gestational age. However, the authors also state that further studies should evaluate the effects of clustered care with more than four procedures (Valizadeh et al., 2014). It would also be relevant to compare clustered care to standard non-clustered care as opposed to comparing different amounts of care interventions that are clustered in order to isolate the effects of this intervention. In fact, standard care should include clustered care but, as shown by a recent observational study, preterm infants in the NICU are still being manipulated more than 143 (SD 41.2) time per 24-hr period (Orsi et al., 2017). Plus, research evaluating the effects during and after the clustering of care on sleep cycles should be undertaken in order to better understand potential interventions protecting preterm infant's sleep in the NICU.

2.3. Recommendations for assessing and managing pain

As for pain management, three key recommendations for practice have been identified. It is essential to effectively manage pain in order to prevent neurodevelopmental repercussions of untreated pain in preterm infants. First, the American Academy of Pediatrics et al. (2016) recommend to systematically evaluate pain scores, for each painful procedure, using a validated pain scale. According to the American Academy of Pediatrics et al. (2016), there are five validated pain scales which can be used with infants: the Neonatal Facial Coding System, the Premature Infant Pain Profile, the Neonatal Pain and Sedation Scale, the Behavioral Infant Pain Profile, and the *Douleur Aiguë du Nouveau-Né*. However, nurses still believed they are able to assess pain without using a validated scale (Polkki et al., 2010). Each NICU should implement a pain scale for clinical purposes and professionals should be trained on how and when to use this pain scale to improve pain assessment. This could potentially raise awareness of the importance of pain management in NICUs (Johnson et al., 2011). Second, for procedural pain management, the American Academy of Pediatrics et al. (2016) recommends combining various pain management interventions such as sucrose and non-nutritive sucking. Combining different interventions, called “multisensorial saturation”, improves pain management in full-term infants (Bellieni et al., 2012). However, this kind of multisensorial intervention has been sporadically studied in preterm infants. Third, engaging and involving parents in pain management, namely by providing them with information on pain management, is also a practice to put forward in NICUs to improve pain management and parental confidence (Franck et al., 2012). According to Axelin et al. (2015), a parent-nurse collaboration for pain management is in the best interest of the infant because it allows for more parent-infant proximity and parental comfort for the infant. For example, their care implication is essential as skin-to-skin (SSC) is an effective intervention to manage pain in preterm infants (Johnston et al., 2017). Collaboration and communication with parents and rethinking the organization of care to enable them to be present during painful procedures and participate in pain management, would reduce the pain of preterm infants during their hospitalization in the NICU (Palomaa et al., 2016).

A lack of research among preterm infants remains in order to support other non-pharmacological interventions for procedural pain management. Some interventions seem beneficial but more high-quality research needs to be conducted before recommending them for practice. This is the case for massage, olfactive stimulation interventions, warming of the heel before heel-prick and control of environmental light and noise (De Clifford-Faugere et al., 2017; Pillai Riddell et al., 2015). Other interventions such as breastfeeding, music, human rocking, co-bedding for twins and mother's voice have not been investigated with a preterm infant population or study results are contradictory (Hartling et al., 2009; Holsti et al., 2011; Pillai Riddell et al., 2015; Shah et al., 2012). Breastfeeding is an effective intervention in term infants, but the transferability of this intervention in preterm infants is still questionable (Shah et al., 2012). Finally, several interventions have been little studied, and the results are inconclusive according to the findings of a systematic review. Those interventions consist of therapeutic touch, administration of water, mechanical rocking, mother's voice and co-bedding for twins (Pillai Riddell et al., 2015).

2.4. Recommendations for infant positioning

In terms of infant positioning, a comprehensive recommendation is to adapt the positioning according to the preterm infant's gestational age as well as his/her individual and developmental needs (Fernandez Rego et al., 2012). Also, a central tenet of positioning is to alternate the positions in order to prevent head asymmetries (Hummel and Fortado, 2005; Waitzman, 2007) which is associated with developmental delays (Martiniuk et al., 2017). It is recommended to recreate the fetal positioning in the NICU, for infants less than 37 weeks of gestational age, which is the positioning that is reported to be the most effective to promote motor development in preterm infants (Blauw-Hospers et al., 2007). Most importantly, preterm infants positioned in prone or side-lying should always be monitored in order to prevent sudden death syndrome (Jarus et al., 2011). Parents are also essential care partners able to participate in their infant's positioning which has shown to improve motor development at term equivalent age compared to preterm infants whose positioning had been done only by health care professionals (Ustad et al., 2016). However, parents need to be supported in how to position their preterm infant and therefore necessitating teaching accordingly (Nightlinger, 2011).

As for effects of positioning on preterm infant's stress, sleep, cerebral blood flow and physiological stability, most published studies are quasi-experimental or observational studies with small sample sizes. For example, a Cochrane systematic review concludes that low to moderate quality evidence support prone positioning to improve oxygenation in preterm infants receiving mechanical ventilation (Rivas-Fernandez et al., 2016). A second Cochrane systematic review concludes that there is a paucity of data to determine the effect of body positioning on heart rate, oxygen saturation or respiratory rate on preterm infants at room air (Ballout et al., 2017). A study recommends semi-prone positioning to stabilize respiratory rate in preterm infants receiving non-invasive ventilation (Yin et al., 2016). Nevertheless, a lack of research remains to support body positioning for physiological stability in preterm infants (Brunherotti et al., 2014; Hough et al., 2012). Also, a quasi-experimental study suggests that there is no statistical difference between prone, supine and side position in terms of behavioral responses (Garcia Santos et al., 2017). Another quasi-experimental study suggests that the supine position is the position where preterm infants seem to demonstrate the most stress cues (Peng et al., 2014b).

Nevertheless, few RCTs have been done to compare positions (prone, supine and lateral) on physiological stability, such as apnea or oxygen saturation, and on stress and behavioral responses which is why more large scale studies are needed in order to better understand the effects of positioning in the NICU (King and Norton, 2017).

2.5. Recommendations for optimized infant-driven feeding

Infant-driven feeding is an approach based on the behavioral assessment of the preterm infants' readiness to initiate and progress with oral feedings (Thoyre et al., 2013). Preterm infants are assessed for their ability to “(1) sustain attention and energy for the duration of feeding, (2) control and organize oral-motor functioning, (3) coordinate swallowing, and (4) maintain physiologic stability” (Thoyre et al., 2013, p. 146). This approach has shown to reduce the time needed for

preterm infants to attain full oral feeding as well as length of hospitalization and better weight gain (Fry et al., 2018; Wellington and Perlman, 2015; Whetten, 2016). To promote infant-driven feeding, NICU healthcare professionals and nurses should provide informational, practical and emotional support to parents in order to promote, establish and maintain breastfeeding in the NICU (Ikonen et al., 2015). An integrative review identified support received during the NICU hospitalization as having a beneficial effect on breastfeeding duration after discharge (Briere et al., 2014). Support should be provided throughout the hospitalization, from the initiation of milk expression promptly after birth to the establishment of full breastfeeding. Milk expression may also be challenging and mothers often put a lot of pressure on themselves. They can feel heartbroken when unable to provide enough breast milk to their preterm infant (Bower et al., 2017). Early, continuous and prolonged SSC should also be encouraged to promote breastfeeding (Nyqvist et al., 2013). As infant readiness to transfer from gavage to breastfeeding is not only based on gestational age but also on neurological and physiological maturity (Whetten, 2016), nurses in collaboration with the healthcare team should respect the infant's maturity and competences when promoting infant driven feeding. Transition from gavage to direct breastfeeding should hence be based on the infant's competences, readiness and maturity (Ziadi et al., 2016). Infant readiness for transfer from gavage to breastfeeding should be managed in an individual manner based on the preterm infant's own developmental status (Davidson et al., 2013). Generally, preterm infants that are ready to transition to breastfeeding can maintain an alert state, have a good tonus, and maintain stable vital signs (Shaker, 2013). Stress signs showing the preterm infant is not ready to breastfeed include weak or no sucking, transition to a sleep state or low tonus during feeding (Gennattasio et al., 2015). Future research should focus on interventions promoting infant driven feeding that would be feasible and sustainable in NICUs (Fry et al., 2018).

2.6. Recommendations for administration of human milk

When breast milk is not sufficient or unavailable, and when the infant meets specific conditions (such as being extremely preterm), parents should be informed about pasteurized donor human milk which is the best alternative to the mother's milk (American Academy of Pediatrics, 2012), when available. The main advantage of pasteurized donor human milk over infant formula is the significantly reduced risk of necrotizing enterocolitis (Quigley and McGuire, 2014). However, pasteurized donor human milk leads to a lower rate of short-term growth in preterm infants compared to formula (Quigley and McGuire, 2014) and their own mother's milk (Montjaux-Regis et al., 2011), and has shown no neurodevelopmental benefits to date (O'Connor et al., 2016; Quigley and McGuire, 2014). Well-designed studies that evaluate how pasteurized donor human milk is introduced and used in preterm infants and its effects on breastfeeding outcomes and preterm infants' neurodevelopment and long-term health outcomes are needed (Williams et al., 2016).

2.7. Recommendations for environmental light and noise

To conclude, control of environmental light and noise should also be adapted to each preterm infant's needs and gestational age. Recent trends NICU design moving towards units composed of single-patient rooms allow for a better control of environmental light and noise levels and adaptation of those levels based on the infants' age. Combining light and noise control is strongly encouraged because it is reported that the sensory experiences to which the sensory system is exposed to, for example hearing, influence the other immature sensory systems, such as the vision (Lickliter, 2000). It is then essential to implement interventions controlling both light intensity and noise levels to which are exposed preterm infants in NICUs.

2.7.1. Light

More specifically, for infants less than 28 weeks of gestational age (White et al., 2013), lighting to be respected should be near darkness (ND) lighting, that being less than 20 lux over a 24-hr period (Morag and Ohlsson, 2016). As for infant more than 28 weeks of gestational age (White et al., 2013), cycled lighting (CL) is recommended, that being 200–225 lux during the day (7:00 a.m. until 7:00 p.m.) and 20 lux for evenings and nights (7:00 p.m. to 7:00 a.m.); (Morag and Ohlsson, 2016; NANN, 2006). Namely, specific interventions to control NICU lighting according to these levels, which can be performed by nurses and other NICU healthcare professionals, are to close ceiling lights at times, procedural lamps after utilization as well as windows' blinds. Apart from these interventions, incubator covers are generally used as a standard practice to control light intensity entering directly infants' incubators and cribs. Also, preterm infants' eyes should never be exposed directly to light, thus covering their eyes during care or procedures is a good practice (White et al., 2013).

2.7.2. Noise

Different strategies can be put forward to reduce the preterm infants' exposure to noise in NICUs. These explicitly include promptly responding to monitors' alarms (Altimier et al., 2015), covering incubators with a blanket, moving noisy equipment away from incubators, setting up an hour of quiet and rest and offering educational programs to NICU professionals about the importance of reducing noise in NICUs (Brown, 2009). As per neonatology experts' recommendations, ambient noise level in NICUs should not exceed 45 dB A on average per hour and should not exceed 50 dB A more than 10% of the time, while the maximum should never exceed 65 dB A (Kilpatrick et al., 2017; White et al., 2013).

When possible and appropriate, parents should be encouraged to participate in the control of NICU environmental light and noise. Strategies which could be performed in NICUs to remind professionals and parents to control light and noise are to consult them and invite them to share their ideas about light and noise control in the neonatal unit in addition to regularly displaying reminder signs to encourage parents and professionals to control light and noise (Aita et al., 2013).

Further research should focus on the effects of CL compared to ND on preterm infants' growth, sleep-wake cycles and neurodevelopment during the hospitalization. The effects of CL should also be further examined on preterm infants' weight gain (Brandon et al., 2017). Effects of continuous ND should also be assessed on the above-mentioned outcomes as well as other interventions controlling preterm infants' exposure to NICU light intensity such as covering incubators. According to a Cochrane review, larger scale RCTs are needed for the NICU sound management to guide clinical practice as the recommended environmental level of 45 dB is not attained in most NICUs (Almadhoob and Ohlsson, 2015; Bott et al., 2015). As well, evaluating the effects of noise reduction intervention on preterm infants' growth, sleep-wake cycles and neurodevelopmental outcomes would allow comparisons with findings of research assessing the effects of light control on the same preterm infants' outcomes. Finally, research could explore parents' perceptions of light and noise control in NICUs.

3. Conclusion

Current evidence regarding DC and core-measures has been addressed using a narrative overview methodology in a previous publication (Lavallée et al., 2019). It has been outlined that DC interventions are a major interest and concern in clinical practice and research to optimize preterm infants' short and long-term health outcomes and neurodevelopment. Following this narrative overview, it was possible to propose practice recommendations that seemed central based on current research literature. Nurses, other NICU healthcare professionals and parents play a central role in delivering DC to preterm infants hospitalized in the NICU. Nevertheless, more RCTs should be conducted

to better understand how DC interventions work and their effects on short and long-term health outcomes. These RCTs should focus on evaluating DC interventions combined and on preterm infants' neurodevelopment during the NICU hospitalization. Understanding how these interventions work during the hospitalization would play a central role to guide NICU clinical practice and further research in this context.

Ethical statement

Ethical approval was not necessary.

Conflicts of interest

We have no conflict of interest to declare.

Funding

We received no external funding.

Acknowledgements

First and second authors would like to acknowledge grants received for their doctoral studies from the Fonds de Recherche en Santé du Québec (FRQ-S). First author also wants to acknowledge a grant received for her doctoral studies from the CHU Sainte-Justine, Montreal, Canada.

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