Early Human Development 90 (2014) 531–534

Contents lists available at ScienceDirect

Early Human Development

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

The effects of skin-to-skin care on the diaphragmatic electrical activity in preterm infants☆

Hanna Soukka [a,*], Linda Grönroos [b], Juha Leppäsalo [a], Liisa Lehtonen [a]

[a] Department of Pediatrics, Turku University Hospital, Finland
[b] University of Turku, Finland

ARTICLE INFO

Article history:
Received 11 December 2013
Received in revised form 17 March 2014
Accepted 14 April 2014

Keywords:
Kangaroo care
Respiratory support
NAVA

ABSTRACT

Background: Skin-to-skin care (SSC) is widely used in neonatal intensive care units due to its positive effects on infant physiology and parent–infant interaction.
Aims: We investigated the safety and the effect of SSC on the diaphragm electrical activity (EAdi) in premature infants recovering from respiratory distress syndrome treated on noninvasive neurally adjusted respiratory assist.
Study design: An observational cross-over study design was used. The infants were evaluated during SSC and in both prone and supine positions before and after SSC during a 9-hour study period. The EAdi was measured via miniaturized sensors incorporated into a feeding tube.
Subjects: Seventeen premature infants with a mean age of 20 d (range, 2–43 d) were studied. Their mean birth weight was 900 g (490–1845 g) and mean gestational age at birth 28 wk (25–32 wk).
Outcome measures: Under each condition, EAdi peak (representing tidal, neural inspiratory effort) and EAdi minimum (representing neural expiratory activity) were numerically quantified. Oxygen saturation, heart rate, and apnea were recorded.
Results: The mean EAdi minimum values were lower during SSC and prone position. In addition, a tendency towards lower EAdi peak values was found during SSC. There were no differences in the occurrence of apnea between the study phases.
Conclusions: SSC is safe and it is not associated with increased neural activity of the diaphragm. On the contrary, low EAdi minimum values were registered reflecting more complete diaphragmatic de-activation between respiratory cycles.

1. Introduction

Skin-to-skin care (SSC) is defined as prolonged time period when an infant ...when an infant **is positioned** skin-to-skin... lays skin-to-skin with their parent. SSC is used especially in preterm infants. SSC is safe and it has positive physiological and psychological effects on both the infant and the parents [1–3]. SSC promotes infant growth, most importantly, brain growth and maturation [4–13]. Further, it may shorten hospital stay [4].

SSC can be applied from the first days of life in very preterm infants when the infants are still likely to have breathing problems [4,14–17]. Early extubation practices have led to prolonged time on non-invasive respiratory therapy when most of the SSC is provided. During this period all infant care should be optimized to decrease work of breathing and promote stability. SSC has a favorable effect on many physiological parameters. It stabilizes heart rate, respiratory rate, and temperature when started immediately after birth or later during the hospital stay [18–20]. In infants close to discharge, SSC has been shown to increase regular breathing and to reduce the incidence of apnea and bradycardia [21], but also conflicting data have been reported [22].

Today, it is possible to clinically measure the electrical activity of the diaphragm (EAdi) in preterm infants [23]. The EAdi is a direct measure of neural respiratory effort, and can provide an indication of diaphragm activity, and in turn lead to interpretations about diaphragm energy expenditure [23]. We wanted to study the safety of SSC from the perspective of work of breathing. We hypothesized that SSC does not increase the neural activity of the diaphragm in preterm infants on non-invasive respiratory support, but may instead lead to lower EAdi values. To test this, we measured EAdi during alternating periods in the incubator and during SSC. In addition, for the incubator periods, we tested the impact of body position (supine vs. prone) on the EAdi.

Abbreviations: SSC, Skin-to-skin care; EAdi, Electrical activity of the diaphragm; NAVA, Neurally adjusted ventilatory assist.

☆ Presented, in part, as oral presentation in sponsored satellite symposia in EAPS 2012, Istanbul, Turkey and in the 6th Nordic Neonatal Meeting in Copenhagen, Denmark 2013.

* Corresponding author at: Department of Pediatrics, Turku University Hospital, Kiinamyllynkatu 4-8, 20500 Turku, Finland. Tel.: +358 41 5053930.
E-mail address: hanna.soukka@tyks.fi (H. Soukka).

http://dx.doi.org/10.1016/j.earlhumdev.2014.04.014
0378-3782/

2. Patients and methods

The study was carried out in the neonatal intensive care unit of the Turku University Hospital (level III NICU) between November 2010 and March 2012. The study was approved by the ethics committee of the hospital district of Southwest Finland as well as by the Pediatric Department of the Turku University Hospital. In addition, written informed consent was obtained from either parents or guardians according to the guidelines of the research and ethics board.

All preterm infants who needed nasal continuous positive airway pressure treatment were eligible for the study. The patient's inclusion criteria were neurological stability without any need for sedatives or anesthetic drugs. Patients with major congenital anomalies or severe intraventricular hemorrhage (grade 3 or 4) were excluded.

There were three separate 3-hour periods in a cross-over study design: the first in an incubator, the second on SSC, and the third in an incubator. Nursing care and feeding took place between the periods. When in the incubator, the infants were studied in both prone and supine positions (90 min each) to take into account the effect of the body position on the EAdi. The study scheme is presented in Fig. 1. In total, 3 conditions were studied. The registrations were performed during the daytime when the parents were present in the unit.

The recordings were performed during non-invasive NAVA (neurally adjusted ventilatory assist) ventilation. The NAVA level, determining the support level, positive end expiratory pressure, and the backup settings in case of apnea were determined by the neonatologist on duty. These settings were kept constant during the study. Apnea time was set to 7 to 10 s. After this time period, NAVA ventilation was automatically replaced by backup ventilation. Backup ventilation might have prevented clinical signs of apnea. When spontaneous breathing returned, NAVA ventilation began again automatically.

The EAdi signal was recorded with an EAdi catheter (Maquet, Solna, Sweden) which includes nine miniaturized electrodes and is positioned in the esophagus at the level of the diaphragm. The EAdi catheter is also used for feeding. The signal was acquired by a ventilator (Servo-I with NAVA option, Maquet, Solna, Sweden), displayed as a waveform, and transferred into a computer with a Servo-tracker program. In addition, oxygen saturation and heart rate were continuously monitored and registered automatically in 5-minute intervals (Masimo pulse oximeter, Irvine, CA). Oxygen saturation was targeted to 90–95% if the patients received supplemental oxygen.

The demographic data are presented as mean value ± SD or 95% CI. EAdi peak (representing the maximal diaphragmatic excitation during a single breath) and EAdi minimum (representing the activity of the diaphragm at end expiration) values were determined for each breath. The number of apnea was defined as the number of switches to backup ventilation. The mean EAdi peak and EAdi minimum values of continuous EAdi, saturation, and heart rate variables were compared between the five periods using mixed model repeated measures analysis with measurement nested within subject as random effect. Other analyses were done using generalized estimating equations with exchangeable working correlation structure. Periods were used as a predictor variable. For the outcome variable, apnea count negative binomial distribution with log link was used and logarithm of duration of measurement was used as offset variable. For the dichotomized saturation outcome binomial distribution with log link was used. The analysis was done using SAS-program version 9.3. p-Value < 0.05 was considered as a statistically significant difference between study periods.

3. Results

A convenience sample of preterm infants was recruited and a total of 17 neonates (12/17 females) were studied. The neonatal characteristics and main diagnoses are presented in Table 1. Caffeine citrate treatment was given to twelve study infants (71%). The mean NAVA level was 0.5 ± 0.2 cm H_2O/μV and the mean positive end expiratory pressure was 4.4 ± 0.7 cm H_2O. Eight patients (47%) received supplemental oxygen.

Moving the infant from prone position to SSC and back in prone position in an incubator did not have an effect on the EAdi peak values (5.4 μV, 5.8 μV and 6.4 μV, respectively). However, during the first prone phase, the EAdi peak value was lower than during both supine phases (5.4 μV vs 6.3 μV and 6.7 μV, $p < 0.05$) (Table 2). The EAdi minimum value was lowest during the first prone and SSC phases (1.7 μV in both) differing significantly from the second prone (2.1 μV) and both supine phases (2.2 μV and 2.1 μV). Heart rate was lower during supine position. There were no differences in respiratory rate or in the occurrence of apnea between the phases (Table 3).

4. Discussion

Our results show that SSC is safe in premature infants and it is associated with decreased electrical activity of the diaphragm comparable to that in the prone position suggesting favorable diaphragm energy expenditure in both of these positions. We used a standardized, non-invasive new method to capture EAdi [24,25]. This signal can be used not only to drive the ventilator but also to assess the impact of various interventions on respiratory pattern and, indirectly, work of breathing. More precisely, the continuous EAdi signal (waveform) provides on-line information about the phasic inspiratory effort of the patient and it can quantify the amount of diaphragm activity present during the end of expiration [23].

Recently, this same technique was used to characterize the neural breathing pattern in spontaneously breathing preterm infants showing that 68% of the breathing of premature infants is regular phasic breathing with relaxation of the diaphragm between breaths (no tonic activity) while 29% of breathing cycles were associated with tonic activity [23]. The preterm lung is especially susceptible to

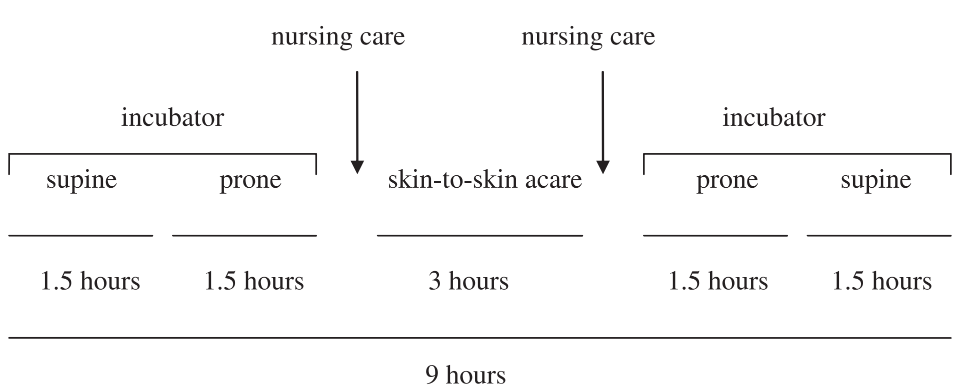

Fig. 1. The scheme of the study. The premature infants ($n = 17$) were recorded for 9 h consisting of three 3-hour periods. Nursing care took place between the periods.