Early Human Development 91 (2015) 71–75

Contents lists available at ScienceDirect

Early Human Development

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

Effects of Sustained Lung Inflation, a lung recruitment maneuver in primary acute respiratory distress syndrome, in respiratory and cerebral outcomes in preterm infants

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ARTICLE INFO

Article history:
Received 27 August 2014
Received in revised form 22 November 2014
Accepted 2 December 2014

Keywords:
Sustained
Neonatal resuscitation
Surfactant
Pulmonary recruitment maneuvers
Iatrogenic risks

ABSTRACT

Background: Sustained Lung Inflation (SLI) is a maneuver of lung recruitment in preterm newborns at birth that can facilitate the achieving of larger inflation volumes, leading to the clearance of lung fluid and formation of functional residual capacity (FRC).
Aim: To investigate if Sustained Lung Inflation (SLI) reduces the need of invasive procedures and iatrogenic risks.
Study design: 78 newborns (gestational age ≤ 34 weeks, weighing ≤ 2000 g) who didn't breathe adequately at birth and needed to receive SLI in addition to other resuscitation maneuvers (2010 guidelines).
Subjects: 78 preterm infants born one after the other in our department of Neonatology of Catania University from 2010 to 2012.
Outcome measures: The need of intubation and surfactant, the ventilation required, radiological signs, the incidence of intraventricular hemorrhage (IVH), periventricular leukomalacia, retinopathy in prematurity from III to IV plus grades, bronchopulmonary dysplasia, patent ductus arteriosus, pneumothorax and necrotizing enterocolitis.
Results: In the SLI group infants needed less intubation in the delivery room (6% vs 21%; $p < 0.01$), less invasive mechanical ventilation (14% vs 55%; $p \leq 0.001$) and shorter duration of ventilation (9.1 days vs 13.8 days; $p \leq 0.001$). There wasn't any difference for nasal continuous positive airway pressure (82% vs 77%; $p = 0.43$); but there was less surfactant administration (54% vs 85%; $p \leq 0.001$) and more infants received INSURE (40% vs 29%; $p = 0.17$). We didn't found any differences in the outcomes, except for more mild intraventricular hemorrhage in the SLI group (23% vs 14%; $p = 0.15$; OR = 1.83).
Conclusion: SLI is easier to perform even with a single operator, it reduces the necessity of more complicated maneuvers and surfactant without statistically evident adverse effects.

1. Introduction

Sustained Lung Inflation (SLI) is a maneuver of lung recruitment characterized by the application of a peak pressure of 25–30 cm H_2O for 10–20 s in preterm newborns at birth. Vyas et al. [1] in 1981, studied the effects of SLI applied for a time of 5 s in preterm newborn resuscitation and proved that this method increased the tidal volume, facilitating the achieving of larger inflation volumes, leading to the clearance of lung fluid and formation of functional residual capacity (FRC) [1]. Lista et al. increased at 10–20 s the time of application of SLI and they asserted that the application of SLI at birth in preterm infants with respiratory distress might decrease the need for mechanical ventilation without inducing evident adverse effects [2]. Harling et al. conversely showed no improvement in the outcome after sustained inflations of 5 s and suggested that immature lungs may be unable to respond to this inflation maneuver [3]. te Pas and Walther showed an increase of complications in the infants treated with SLI, such as severe intraventricular hemorrhage, although they did not reach a statistical significance [4]. In this retrospective cohort study, we analyze the outcome and the onset of complications in infants receiving (SLI group) and infants not receiving it (conventional group).

Abbreviations: AHA, American Heart Association; BPD, bronchopulmonary dysplasia; CI, confidence interval; FiO_2, fraction of inspired oxygen; FRC, functional residual capacity; INSURE, INtubation, a dose of SURfactant and Extubation; IUGR, intrauterine growth restriction; IVH, intraventricular hemorrhage; MAP, mean airway pressure; n-CPAP, nasal continuous positive airway pressure; NICU, neonatal intensive care unit; OR, odds ratio; pCO_2, pressure of carbon dioxide; PDA, patent ductus arteriosus; PMA, postmenstrual age; PEEP, positive end-expiratory pressure; PROM, premature rupture of membrane; RDS, respiratory distress syndrome; SaO_2, arterial oxygenation saturation; SD, standard deviation; SLI, Sustained Lung Inflation.

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http://dx.doi.org/10.1016/j.earlhumdev.2014.12.002
0378-3782/

2. Patients and methods

We conducted an observational analytical cross-sectional case–control study on 78 infants born one after the other in our department of Neonatology of Catania University from 2010 to 2012.

The study was conducted in accordance with the Helsinki Declaration, and the study protocol was approved by the (local) Ethics Committee of the Medical University of Catania.

Inclusion criteria comprised gestational age ≤34 weeks, weight ≤2000 grams (g), absence or inadequate breathing at birth and performance of SLI [5] in addition to the other resuscitation maneuvers according to the guidelines of 2010 [6] (SLI group). Exclusion criteria comprised major congenital anomalies.

We have analyzed the need of intubation and surfactant administration, the type and duration of ventilation required, radiological signs of severe respiratory distress, the timing of hospitalization and the growth of the infants. We have also studied the outcome focusing on the incidence of intraventricular hemorrhage (IVH), periventricular leukomalacia, retinopathy in prematurity from III to IV plus grades, bronchopulmonary dysplasia, patent ductus arteriosus, pneumothorax and necrotizing enterocolitis. According to NIH Consensus Development Conference we defined intraventricular hemorrhage (IVH) as a spectrum of hemorrhagic brain injury most typically occurring in the first week of life in very premature infant and periventricular leukomalacia as focal cystic damage of white matter tracts (made of nerve axons that connect different brain regions covered by the insulating substance, myelin) [7]. According to the National Institutes of Child Health and Human Development Neonatal Research Network we distinguished bronchopulmonary dysplasia (BPD) in mild BPD defined as a need for supplemental oxygen (O_2) for ≥28 days but not at 36 weeks' postmenstrual age (PMA) or discharge, moderate BPD as O_2 for ≥28 days plus treatment with <30% O_2 at 36 weeks' PMA, and severe BPD as O_2 for ≥28 days plus ≥30% O_2 and/or positive pressure at 36 weeks' PMA [8].

We compared the data of patients with those of a control group of 78 infants with the same gestational age and weight, born one after the other in our department of Neonatology of Catania University from 2008 to 2010, requiring resuscitation maneuvers at birth (conventional group) according to the guidelines of 2010 [9].

2.1. Statistical analysis

Statistical data were derived using Student's t test for parametric and the Mann–Whitney U test for non-parametric continuous variables and $\chi 2$ test for categorical variables. p values were considered statistically significant if $p < 0.05$. For the categorical variables we analyzed the odds ratio (OR) with the 95% confidence interval.

2.2. Resuscitation maneuvers in the delivery room

Newborns in the SLI group received only one 25 cm H_2O pressure controlled inflation for 15 s using a face mask of appropriate size for each of them and a T-piece ventilator [5,6,10]. If required, after SLI, infants were resuscitated according to the maneuvers required by the American Heart Association (AHA) 2010 neonatal resuscitation guidelines [6] or received a 4 cm H_2O continuous positive airway pressure (CPAP) [4]. Newborns in the control group received conventional resuscitation maneuvers which consist in a first initial inflation of 30–40 cm H_2O, followed by insufflations not exceeding 20 cm H_2O, with a rate of 60 per minute and a PEEP of 5 cm H_2O using a face mask of appropriate size and a T-piece ventilator (Neopuff). Positive pressure ventilation was started with FiO_2 at 21% [7,10]. FiO_2 was subsequently incremented if necessary [7].

In both groups newborns were intubated and mechanically ventilated if, despite the correct resuscitation maneuvers, the heart rate did not increase above 100 beats per minute, if breathing was absent, if cyanosis persisted or dyspnea occurred [6]. All infants, after stabilization and an observation period, were transferred to the NICU. Newborns who did not need intubation were transferred with nasal CPAP and their oxygen saturation was monitored [6].

2.3. Maneuvers at the NICU

Soon as the infant arrived in NICU pulse oximetry values, objective data and chest radiographs were collected. Infants were intubated and mechanically ventilated if they had oxygen saturation values ≤88% while receiving $FiO_2 \geq 40\%$, or $pCO_2 > 60$ mm Hg with a pH < 7.20, or if they had more than 4 apneic episodes in 1 h.

Therapy with caffeine was started as soon as possible in infants younger than 30 weeks and in older infants who had apnea. All intubated newborns received, immediately, a dose of surfactant (Curosurf, Chiesi, Italy) while for newborns who required ventilatory assistance with MAP > 7 cm H_2O and $FiO_2 > 40\%$ a second dose of surfactant was performed at a distance of at least 6 h after the first dose [10]. No intubated preterm infants who showed clinical features of respiratory distress syndrome (RDS) such us sternal, intercostal or subcostal retraction, grunting, tachypnea and the need of oxygen supplementation, received INtubation, a dose of SURfactant and shortly after Extubation (INSURE) [10–12].

We proceeded to the extubation as soon as FiO_2 needed was lowered <30% and the mean airway pressure <7 cm H_2O. We continued with nasal continuous positive airway pressure (n-CPAP) ventilation until infants had no sign of distress and were stable with $pCO_2 < 60$ mm Hg and $SaO_2 > 92\%$ without supplementary O_2. All infants received a cerebral ultrasound study and a retinal examination from the 21st day of life and subsequent checks if necessary.

The management at the NICU was the same in both the SLI and conventional groups.

3. Results

The SLI group presented a mean gestational age of 30.4 weeks (range 23 to 33.5 weeks) and a mean weight of 1.335 g ± 376 (range 335 to 1975 g). The control group did not present a significant difference in both gestational age (mean 30.5 weeks; range 22 to 34 weeks) and weight (mean 1371 g ± 411; 400 to 2000 g).

The demographic characteristics of both groups are shown in Table 1. Six newborns in the SLI group (8%) and five newborns in the control group (6%) died during their first two weeks of life, while one newborn in the SLI group (1%) and four in the control group (5%) died subsequently.

In the SLI group fewer infants than in the control group required intubation in the delivery room (5 of 78 [6%] vs 16 of 78 [21%]; p = 0.009; odds ratio (OR) = 0.27; confidence interval (CI) = 0.09–0.77). Infants

Table 1
Demographic characteristics.

	Sustained (N = 78)	Conventional (N = 78)
Gestational age, mean (SD), wk	30.4 (±2,6)	30.5 (±3.1)
Birth weight, mean (SD), g	1335 (±376)	1371 (±411)
Male gender, n (%)	39 (50)	38 (49)
Twin, n (%)	40 (51)	24 (31)
Cesarean birth, n (%)	65 (83)	66 (85)
PROM, n (%)	12 (15)	15 (19)
Chorionamionite, n (%)	9 (12)	8 (10)
Prenatal steroids, n (%)	65 (83)	63 (81)
IUGR, n (%)	4 (5)	5 (6)
Cordonal pH, mean (SD)	7.25 (±0,20)	7.23 (±0.22)
5′ Apgar score < 6, n (%)	5 (6)	16 (21)
5′ Apgar score, median	8	8
Growth, median	22	21
Died <2 weeks old, n (%)	6 (8)	5 (6)

IUGR, intrauterine growth restriction; n, number; PROM, premature rupture of membrane; SD, standard deviation; wk, weeks.