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Research Article

Effectiveness and Impact of Different Positive Pressure Ventilation Techniques on Neonatal Resuscitation and Bronchopulmonary Dysplasia; Systematic Review

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Abstract

Background: Positive pressure ventilation with a face mask or nasal prongs is advised at birth according to the most recent guidelines for neonatal resuscitation. Newborn infant outcomes could be enhanced by the use of a nasal interface. The purpose of this systematic review study was to ascertain how various PPV techniques affected infant resuscitation and how the rate of BPD decreased.

Method: This systematic review was conducted in accordance to PRISMA guidlines. We searched MEDLINE, Google Scholar, and EMBASE online databases. In addition, we manually searched the references in the articles that our search strategy had turned up. Only publications published between 2005 and 2023 in the English language were included.

Results: In this systematic review study we included 7 RCTs, with a total of 1735 participants. Four of the studies compared SLI with conventional care. Three studies compared face mask with single nasal prongs, Nasal cannula and nasal tube. Face mask is not superior either to SNP or nasal tube in providing PPV during neonatal resuscitation. Nasal cannula was found to be more effective in oxygen delivery during neonatal resuscitation when compared to oral route. According to 2 of the included studies there is no significant benefits after the use of sustained lung infaltion in the resuscitation.

Conclusion: Nasal cannula was more effective in oxygen delivery during neonatal resuscitation when compared to oral route. treatment failure less occured in sustained-pressure controlled ventilation compared to intermittent mandatory ventilation.

Keywords: Neonatal Resuscitation; Positive Pressure Ventilation; Delivery Room; Preterm Infants

Introduction

Between 5% and 10% of all newborns get neonatal resuscitation after birth, making it one of the most frequently used medical procedures [1]. The provision of efficient aided inflations is the cornerstone of neonatal resuscitation in the delivery room (DR). The first ventilation after birth should be achieved using a face mask and a manual breathing device, according to international standards for newborn resuscitation [2]. Successful ventilation

depends on the infant's upper airway being positioned correctly and the mask and face sealing tightly [3].

However, leaks around the face mask are frequent and upper airway obstruction can happen when manually applying positive-pressure ventilation (PPV) to newborns, which can result in insufficient ventilation [4,5]. Many times, mask leaks and obstructions during mask PPV go unnoticed [4]. They could hinder the delivery of the proper tidal volumes and the predetermined positive end-expiratory pressure (PEEP), which would delay the establishment of efficient gas exchange [4]. The current guidelines include using a face mask that fits properly and providing PEEP if it is available for the stabilization of preterm newborns in the DR [2]. In order to lessen lung damage and, consequently, short- and long-term morbidity, gentle breathing techniques have been recommended to help with lung aeration after birth [6,7].

Although there are several contributing factors to the pathophysiology of bronchopulmonary dysplasia, ventilator-induced lung injury is one of the main ones [8]. Although several novel ventilation techniques have been implemented, the prevalence of bronchopulmonary dysplasia (BPD) has not decreased as a result [9]. There is disagreement about the early ventilatory care of preterm children due to a lack of data, despite the possibility that early respiratory management—that is, ventilatory support from birth during the first few days of life—may affect the pulmonary prognosis.3. Studies using experimental and retrospective cohort data indicate that the early ventilation plan may have a significant impact on the development of BPD [10,11]. The purpose of this systematic review study was to ascertain the impact of various PPV techniques on neonatal resuscitation and the decline in the BPD rate.

Methods

This systematic review was conducted in accordance to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidlines, with the following search terms: newborn, infant, neonate, resuscitation, nasal prong, facemask, positive pressure ventilation, sustained lung inflation (SLI). We searched MEDLINE, Google Scholar, and EMBASE online databases. In addition, we manually searched the references in the articles that our search strategy had turned up. Only publications published between 2005 and 2023 in the English language were included. Excluded from consideration were studies done on older individuals or children or outside delivery rooms. We did not include research done in simulation.

Authors evaluated each study's eligibility based on their own judgments of the abstract and title. Following that, complete texts were obtained and added in accordance with the qualifying requirements. Discussions were used to settle any disputes. The only studies that were included were randomised controlled trials that compared different PPV techniques for newborns receiving neonatal resuscitation in the delivery room.

A standardized collecting form that comprised the study design and procedures, patient characteristics, interventions, and principal findings was used to extract data. To avoid duplicate or missing data, the authors manually extracted the information using a Google form and a Google sheet that they had access to beforehand. After separately extracting data and discussing differences with the supervisor, each author rectified any conflicts.

Results

In this systematic review study we included 7 Randomized controlled trials (RCTs) (Figure 1), with a total of 1735 participants. Four of the studies [12-15] compared SLI with conventional care. McCarthy., *et al*. 2013 [16]; Capasso., *et al*. 2005 [17] and Kamlin., *et al*. 2013 [18] compared face mask with single nasal prongs (SNP), Nasal cannula and nasal tube respectively (Table 1).

Citation	Study aim	Population characteristics	Study design	Treatment arms
McCarthy., *et al*. 2013 [16]	To determine the effectiveness of FM versus SNP	Less than 31 weeks gestational age (GA) neonates	RCT	SNP, n = 72 FM, n = 72
Capasso., *et al*. 2005 [17]	To assess oxygen delivery in PPV via FM versus nasal cannula	Neonates who are presented a live with cyanosis, poor respiration, 60 to 100 heart rate, reactivity and tone.	RCT	Nasal cannula group, n = 303 Mask group, n = 314

Kamlin., *et al.* 2013 [18]	Safety and efficacy of nasal tube versus silicon FM in neonatal resuscitation	Infant with gestational age (GA) from 24 to 29 weeks who needed resuscitation	RCT	Arm 1 : nasal tube n = 178 Arm 2: FM n = 185
Lindner., *et al.* 2004 [19]	To test if the nasopharyngeal tube pressure control ventilation is more effective than nasopharyngeal intermittent mandatory ventilation In establishing suffusion gaze exchange and spontaneous breathing in preterm neonate	Preterm neonate with GA 25+0 to 28+9 weeks with heart rate less than 100 beat per minute and do not have severe malformation, less than 20 week gestational age, oligohydraminous, and feto-fetal transfusion syndrome	RCT	Arm 1 :sustained pressure controlled inflation n = 31 intermittent mandatory ventilation N = 30
Lista., *et al.* 2015 [15]	To test if the use of SLI in combination with nCPAP reduce MV need and improve outcome in preterm neonate	Neonates with GA of 25+0 to 28+6 without congenital malformations or fetal hydrops	RCT	Control group N = 143 SLI group N = 148
Harling., *et al.* 2005 [13]	To investigate the use of SLI to reduce lung injury in premature neonatal resuscitation	Neonate less than 31 weeks GA who needed resuscitation at birth	RCT	SLI group n = 26 Conventional lung inflation group n = 26
te Pas., *et al.* 2007 [12]	To compare SLI with early nasal CPAP with conventional intervention in the resuscitation of preterm neonate	Preterm neonate less than 33 week GA free of congenital malformations	RCT	SLI group n = 104 Conventional group n = 103

Table 1: Characteristics of included studies.

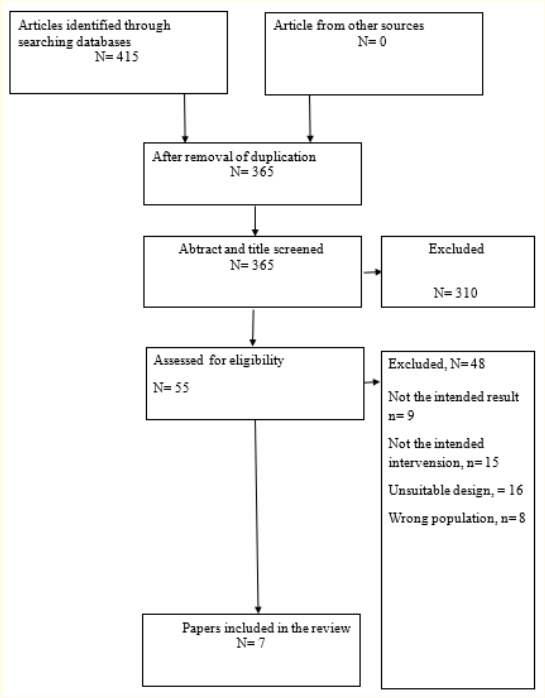

Figure 1: PRISMA consort chart of selection process.

McCarthy., *et al.* 2013 [16] coducted study to determine the effectiveness of face mask (FM) vs SNP. Kamlin 2013 conducted study to compare the safety and efficacy of nasal tube versus FM in neonatal resuscitation they found that FM is not superior either to SNP or nasal tube in providing PPV during neonatal resuscitation. Nasal cannula was found to be more effective in oxygen delivery during neonatal resuscitation when compared to oral route according to Capasso., *et al.* 2005 [17].

Lindner., *et al.* 2004 [14] found that treatment failure occurred In 70% and 61% of intermittent mandatory ventilation and sustained-pressure controlled ventilation groups respectively and 30% of both study arms achieved spontaneous breathing in the first 48 hours. Lista., *et al.* 2015 [15] found that SLI in combination with neonatal continious positive aireway pressure (nCPAP) decrease the need of mechanical ventilation (MV) in preterm neonate compared with nCPAP alone.

Harling., *et al.* 2005 [13] conducted study to investigate the use of SLI to reduce lung injury in premature neonatal resuscitation and found that no significant benefits after the use of SLI in the

resuscitation. Tepas., *et al*. 2007 [12] compared SLI with early nasal CPAP with conventional intervention in the resuscitation of preterm neonate and found that the duration of ventilator support and the rate of intubation was less in the SLI group (Table 2).

Citation	Main results	Conclusion
McCarthy., *et al*. 2013 [16]	The intubation rate was not different between the groups. SpO2 was lower in SNP group at 5 minutes. SNP group received the maximum oxygen concentration in the delivery room	There is no significant difference between FM and SNP regarding ventilation and intubation in the delivery room
Capasso., *et al*. 2005 [17]	Authors found that chest compression and intubation are less needed when nasal root is used for resuscitation. admission to neonatal intensive care unit (NICU), Appearance, Pulse, Grimace, Activity and Respiration (APGAR) score, birth weight, air leak syndrome, GA, steroid use, and mortality did not differ between the groups	Nasal cannula, oxygen delivery in positive pressure ventilation in neonatal resuscitation is a good alternative to oral route
Kamlin., *et al*. 2013 [18]	The rate of intubation in the first 24h were 55% and 54% in the FM group and nasal tube group respectively (OR = 0,97)	There is no significant difference between FM and nasal tube in providing PPV in the delivery room
Lindner., *et al*. 2004 [19]	Treatment failure occurred In 70% and 61% of intermittent mandatory ventilation and sustained-pressure controlled ventilation groups respectively. mortality rate, chronic lung disease , and intra-ventricular hemorrhage were not different between the study arms	30% of both study arms achieved spontaneous breathing in the first 48 hours without MV and endotracheal intubation
Lista., *et al*. 2015 [15]	In SLI group there is significantly less infants ventilated in comparison to control group. Respiratory support need and survival rate did not differ significantly between the groups. the incidence of pneumothorax was 6% in the SLI group and 1% In the control group	SLI in combination with nCPAP decrease the need of MV in preterm neonate compared with nCPAP alone but it did not decrease the occurrence of Broncho-pulmonary dysplasia and respiratory support need
Harling., *et al*. 2005 [13]	23% of neonates died in the SLI group, while 11.5% died in the conventional group. 53.8% and 50% survived without Broncho pulmonary dysplasia (BPD) respectively	No significant benefits was detected after the use of SLI in the resuscitation of premature neonates
te Pas., *et al*. 2007 [12]	The duration of ventilator support and the rate of intubation was less in the SLI group as well as the development of BPD	SLI with early nasal CPAP was more effective than manual inflation using self-inflating bag in early premature neonatal resuscitation

Table 2: Main findings of omc;uded studies.

Discussion

In this systematic review, various PPV techniques were examined in the delivery room for premature neoborns delivered before 37 weeks of gestation. Our review contained seven studies. According to 4 of the included studies [16-18,20] there was no discernible difference in neonatal mortality between the use of SNP and FM. Utilizing SNP or tubes decreased the intubation rate and chest compression in the DR, on the other hand utilizing a FM

decreased the intraventricular hemorrhage risk. While Kamlin., *et al*. and McCarthy., *et al*. [16,18] employed oxygen concentrations between 21% to 30%, Capasso., *et al*. and Te Pas., *et al*. [17,20] used oxygen concentration of 100%.

The results of Kamlin., *et al*. study indicate that FM and nasal tube are suitable interfaces for preterm newborns stabilization in the DR. A study by Kamlin., *et al*. suggested that a nasal tube would be a good substitute for the FM that is advised by the international resuscitation committee [2] while providing PPV to premature newborns. Thus, an individual unit's approach may be determined by personal decision and local experience in accordance with International Resuscitation Committee principles [2].

The findings of the Maccarthy., *et al*. [16] study are different from those of earlier research that showed using an SNP rather than an FM reduced the risk of DR respiratory support and BPD in preterm neoborns [14,20]. These studies assessed ventilation equipment, modalities of ventilation, and interfaces in tandem with other areas of DR care. It is likely that factors other than the use of a nasal interface in DR care contributed to the outcome improvements seen in these trials [14,20].

According to te Pas., *et al*. [20] study, less MV is needed in preterm neonates as well as the need for NICU when a prolonged inflation through a nasal tube is used immediately after nasal CPAP is used instead of bag and FM ventilation and CPAP on admission to the NICU. The findings of the Lindner., *et al*. [14] study, which contrasted the same lung recruitment method and early nasal CPAP in 1996 with elective intubation as a historical control in 1994, are in line with the findings of the te Pas., *et al*. study [20].

Lista., *et al*. [15] report that SLI was successful in reducing the requirement for MV during the first few days of life, as 53% of newborns were placed on MV, compared to 65% in the control group, with no discernible negative effects. These results could be explained by the Functional residual capacity [FRC] attainment and lung recruitment that SLI offers, as well as the lung collapse prevention that PEEP permits. Additionally, SLI may enhance exogenous surfactant dispersion [21] and significantly boost pulmonary blood flow, which would accelerate circulatory recovery [22].

The SLI method in conjunction with early nCPAP did not reduce the total requirement for and duration of noninvasive respiratory support and MV, the need for surfactant, or the incidence of BPD, according to the Lista., *et al*. [15] trial. Although both of these trials lacked power due to small sample sizes, the results of the Lista., *et al*. [15] study are consistent with those of the studies by Lindner., *et al*. [19] and Harling., *et al*. [13]. Although the SLI method reduced the average length of ventilatory support and the incidence of BPD, te Pas., *et al*. [8] also reported a decrease in the need for MV at 72 hours of life.

Infants in the SLI group in the study by te Pas., *et al*. [20] were helped in the delivery room with a T-piece ventilator that can provide a consistent PEEP, while infants in the control group were helped with a self-inflating bag that only provides a minimal amount of PEEP. The control group in the Lista., *et al*. [15] research received nCPAP treatment in the delivery room using a T-piece ventilator that produced a PEEP of 5 cm H2O.

Consequently, the early delivery of SLI + PEEP rather than SLI a lone may be the cause of the decrease in BPD shown in the te Pas., *et al*. study group, and this impact may be amplified by the control group's lack of PEEP. In a rabbit model of RDS, it has been shown that whereas ventilation with PEEP but not a SLI progressively recruits FRC, ventilation without either PEEP or a SLI prevents FRC recruitment [23]. Therefore, the BPD-preventing impact of SLI in the Lista., *et al*. trial may have been mitigated by the nCPAP delivery to the control infants, enabling them to gradually acquire FRC even in the absence of SLI.

These factors appear to be supported by the comparable BPD occurrences in the studies by Lista., *et al*. [15] and the control group in te Pas., *et al*. [20]. Despite the fact that the GA of the control group in the te Pas., *et al*. [20] study was nearly three weeks higher than that of the Lista., *et al*. [15] study, this data suggests a similar risk of developing BPD, which may be explained by the absence of PEEP delivery in the delivery room.

Conclusion

Nasal cannula was more effective in oxygen delivery during neonatal resuscitation when compared to oral route. treatment failure less occured in sustained-pressure controlled ventilation

compared to intermittent mandatory ventilation. SLI in combination with nCPAP decrease the need of MV in preterm neonate compared with nCPAP alone. Duration of ventilator support and the rate of intubation was less when SLI was used.

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