Title: Neonatal Cranial Molding and Positioning Changes Related to Respiratory Device – Evidence Table

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Databases Searched: PubMed, CINHAL, EMBASE, Cochrane Library, Google Scholar

Title, Author, Year	**Subjects**	**Inclusion and Exclusion Criteria**	**Outcome Measure**	**Measurement Timeframe**	**Interventions**	**Results**	**Conclusions**	**Implications for Study**
Evaluating the effectiveness of gel pillows for reducing bilateral head flattening in preterm infants: a randomized controlled pilot study, Schultz, 2008[1]	Informed consent was obtained for 87 infants; however, 36 males and 45 females were randomized to the experimental group (with an n of 41) and control group (with an n of 40).	Inclusion: Infants were eligible for the study if they were less then 32 weeks of age, weighed less than 1,500g, and did not have hydrocephaly, microcephaly, cranial deformities, and/or central nervous system abnormalities.	A cranial index of > 1.40 was used to signify undesirable molding or plagiocephaly. Demographic information of gestational age, birth weight, gender, type of delivery, days on a ventilator, and general health was collected from patient charts.	Baseline measurements were taken no later than 72 hours into life. Then, head measurements were taken every 7 days from the day of admission to discharge.	Infants in the control groups were placed on the standard foam core mattress, which is 2.5 cm thick. The Gel- E Donut pillow was placed under the sheet of the mattress and infants had their torsos elevated to the level of the pillow to provide proper spinal curvature, neck flexion, and airway obstruction.	The use of gel pillows did not significantly reduce the degree of bilateral head molding. Using repeated measures analysis of variance (RMANOVA), there was no noted statistically significant difference in CI (p=0.348) or OFC (p=0.867) between the two groups. The average CI for subjects	While this article more specifically assesses a positional device on head shape, it acknowledges that a regimented positional protocol further reduces head molding and is needed for preterm infants. This article targets my exact population (under 32 weeks of birth gestational age) and demonstrates	Evaluating the effectiveness of gel pillows for reducing bilateral head flattening in preterm infants: a randomized controlled pilot study, Schultz, 2008

						in the control group was 1.41 (SD= 0.085) and the mean CI for the experimental group was 1.40 (SD = 0.066).	long-term impacts of head shape such as asymmetric motor performance.	
Dolichocephaly in Preterm Infants: Prevalence, Risk Factors, and Early Motor Outcomes, McCarty, 2017[2]	A total of 143 infants were enrolled and of these, 65 infants met the inclusion criteria.	Inclusion: Birth weight of <1,500g and/ or PMA <32 weeks, stable on room air, nasal cannula, or CPAP. Exclusion: genetic abnormality, neuromuscular disorder, craniofacial abnormality, congenital or posthemorrhagic hydrocephalus, or other diagnosis determined to impact generalizabilit	CI was determined by measuring biparietal diameter (BiPD) to occipitofrontal diameter (OFD). BiPD is defined as the widest transverse diameter of the head and OFD is the diameter of the head from the most prominent midline point of the frontal bone to the occipital protuberance. Dolichocephaly was defined	Retrospective review method was utilized	Physical therapists would use these values to monitor head shape changes overtime to educate caregivers about optimal positioning.	Overall, 35 infants (54%) developed dolichocephaly at some point during their hospital stint. A total of 43 infants (66%) received an initial physical therapy evaluation when they were < 32 weeks' PMA, and of these, 4 (9%) had dolichocephaly. Of the 65 infants measured during the 32 to 34 weeks'	This article directly targets how dolichocephaly develops and is impacted by positional change. Authors describe that direct positional change intervention is needed to decrease the prevalence of dolichocephaly in very premature infants. Authors describe how supine is the	Dolichocephaly post prevalent at 32-34 weeks and can lead to decreased developmental stages in outpatient PT Supine is best position to limit dolichocephaly but not great for developmental care and secondary conditions

		y of results.	as CI <76%. Adverse motor outcomes in outpatient PT.			PMA period, 25 (39%) had dolichocephaly. Out of the 65 total number of participants, 57 infants were measured at hospital discharge and 19 (33%) had dolichocephaly. At the follow-up visit, 6 out of 50 (12%) had dolichocephaly.	best position to limit development of dolichocephaly; however, note that this position is not ideal for developmental care and many secondary conditions these infants often present with.	
Effect of Change of Mechanical Ventilation Position on the Treatment of Neonatal Respiratory Failure. Wu, 2015[3]	67 neonates	Inclusion: neonates with confirmed respiratory failure Exclusion: severe thoracic deformity, unstable hemodynamics, increased intracranial pressure, acute	Ventilator associated: FiO2, PIP, PEEP, RR Oxygenation: OI = oxygenation index (PaO2/FiO2) PaO2, PaCO2, pulmonary dynamic compliance (Cdy), tidal volume (VT),	Measurements at the 8th and 16th hour in both groups	Supine group: remained supine for all hours Alternate Group: placed supine for 4h and then prone for 4h.	Statistically significant differences ($P<0.05$) in PaO2, OI, Cdy, and VT in the alternate and supine groups. Overall the alternate group showed more statistically significant oxygenation	Oxygenation and respiration are significantly improved with alternating positions. Prone position can improve oxygenation and decrease adverse	Alternating positions, particularly to prone is necessary for neonates. Patients with severe ARDS should be placed in prone as soon as possible.

		hemorrhage, pneumothorax, intolerance to prone ventilation, and rapidly deteriorating vitals in prone	and minute ventilation (MV)			parameters.	reactions.	
Prevalence of head deformities in preterm infants at term equivalent age. Ifflaender, 2013[4]	195 patients divided into 3 groups by gestational age. Very preterm (>32 wk) Preterm (32-36 wk) and term (37-40) weeks.	Inclusion: preterm infants Exclusion: peripheral IV at the scalp and those requiring supplemental oxygen	Three dimensional infant head shape. Cranial vault asymmetry index (CVAI)	Scanned at term equivalent age. (TEA) Infants may have been scanned before during their stay in the NICU also.	N/A	CVAI was significantly higher in the very preterm infant group when compared to the other groups. 15% of term infants, 18% of preterm infants, and 38% of very preterm infants developed moderate or severe plagiocephaly. Cranial index (CI) was also significantly lower in very preterm infants. They were also more likely to develop	Preterm birth and duration of total respiratory support (particularly CPAP) were significantly associated with the development of abnormal cranial molding. (CI, dolichocephaly, plagiocephaly)	Prematurity and use of CPAP for respiratory support predispose infants to development of abnormal cranial molding.

						dolichocephaly.		
Effects of positioning on breathing pattern of preterm infants. Heimler, 1992[5]	14 stable preterm infants.	Inclusion: preterm ranging in 26-36 week gestational age, recent clinical apnea Exclusion: other condition besides clinical apnea or respiratory distress. Bronchopulmonary dysplasia. Respiratory support of oxygen.	Breathing pattern via pneumogram	Consecutive nocturnal 12 hour impedance pneumograms, 1 in prone and 1 in supine.	Positioning.	Significant increase in apnea density in supine versus prone (p=0.01). Supine resulted in a 77% increase in periodic breathing (p = 0.015). Increase in postprandial apnea during nights in supine.	Increased in incidence in supine compared with prone position.	Prone is beneficial for respiration and preventing apneic episodes in spontaneously breathing preterm infants.
The effects of alternative positioning on preterm infants in the neonatal intensive care unit: A randomized clinical trial.	100 preterm infants	Inclusion: preterm (<32 weeks). Exclusion: congenital abnormality	NNNS (NICU Network Neurobehavioral Scale), days on ventilator, days on oxygen, PMA at discharge.	Between 35-40 weeks PMA	Alternative positioning device (Dandle Roo, holding legs in WB flexed position) or traditional positioning.	Infants in alternative positioning demonstrated less asymmetry during NNNS. Sub-analysis of infants born >28 weeks in alternative positioning demonstrated	Positioning of preterm infants in the NICU has important developmental effects.	Positioning of preterm infants in the NICU has important developmental effects.

Madlinger-Lewis, 2013[6]						less asymmetry.		
Positioning for acute respiratory distress in hospitalized infants and children. Gillies, 2012[7]	24 studies, a total of 581 participants. Most participants, but not all, were ventilated preterm infants.	Inclusion: RCTs or pseudo-RCT comparing 2 or more positions in the management of infants hospitalized with acute respiratory distress.	A variety, since it is a systematic review. Main outcomes were oxygen saturation, arterial oxygen, and episodes of hypoxemia.	Varies by study	Supine and prone positioning via various studies.	Prone positioning was significantly more beneficial than supine for oxygen saturation, arterial oxygenation, and episodes of hypoxemia.	Prone positioning was significantly superior to the supine in terms of oxygenation, and most of the data extracted was from preterm infants on ventilation.	Prone positioning is relevant to the preterm infant population and has statistically significant synthesized data from multiple studies indicating it's benefits over supine.
Positioning effects on lung function and breathing pattern in premature newborns. Gouna, 2013[8]	19 preterm infants receiving mechanical ventilation for respiratory distress and surfactant treatment in the first hour of life	Inclusion: preterm birth 26-30wks GA, spontaneous breathing with CPAP, mild respiratory failure O2 requirement 22-33% to maintain 88-95% SpO2 Exclusion: circulatory failure, vasoactive drugs, periventricular	SpO2, PaCO2, HR, RR, arterial blood pressure, apneic episodes.	Variables measured every 3 hours	Supine, left lateral, and prone positioning. Each infant placed in random order in all of the positions with respiratory variables measured every 3 hours.	Fraction of inspired oxygen was similar in all 3 positions. SpO2 and tidal volume was higher in left lateral and prone. Fewer apneic and hypoxic episodes in left lateral and prone.	The left lateral and prone position have similar respiratory effects, and the left lateral can serve as an alternative to prone position in the oxygen-dependent preterm infants in the NICU.	Prone and left lateral have superior respiratory effects when compared to supine. Left lateral can serve as an alternative to reduce the risk of adverse impacts of prolonged prone positioning.

		leukomalacia, or intraventricular hemorrhage.						
Effect of body position on preterm newborns receiving continuous positive airway pressure. Brunherotti, 2014[9]	16 premature infants	Inclusion: preterm 26-33 weeks, <2000 grams, respiratory distress syndrome, use of CPAP Exclusion: congenital malformations, severe anoxia, hydrocephalus, abdominal surgery, bronchopulmonary dysplasia, severe agitation	RR, HR, SpO2.	Infants kept in each position for 60 minutes and the stats were recorded in intervals of 10 minutes.	Cross-over design. Supine, right lateral, left lateral, and prone all assessed in a different order after random assignment.	No statistically significant difference in HR or RR in any positions but there were more tachypnea events in supine. Significant differences in SpO2 between supine/left and prone/right, with the highest oxygen saturation observed in prone.	In conclusion, in preterm newborns receiving nasal CPAP that are in good clinical condition and well adapted to the pressure system, cardiopulmonary indicators were similar in the four decubitus positions. There was no position for preterm newborns receiving nasal CPAP, but the left and right lateral positions were less advantageous in terms of	Prone still reigns as the best for vials and oxygen.

							oxygen saturation.	
Effect of time and body position on ventilation in premature infants. Hough, 2016[10]	60 premature infants. 48 dependent on respiratory support (24 mechanical vent, 24 CPAP), 12 spontaneously breathing.	Criteria not noted.	Regional impedance amplitude, end expiratory level, ventilation homogeneity, RR, fractured inspired oxygen, HR.	4 hours in each position, but measurements taken after the first 30 minutes in that position This study was further analyzing the data of a previous study by the same author.	4 hours each position.	Regional impedance amplitude increased over time at CPAP, peaking at 2 and 4 hours. Significant increase in EEL at 2 hours, but returned at baseline at 4 hours. No clinically or statistically significant changes in vitals.	Regional ventilation distribution and EEL is influenced by time with the effect being independent of body position.	There is a time dependent component of respiration and oxygenation that is independent of position. Infants stabilize and increase oxygenation parameters with time (2-4 hours) in a position.
Prevalence and predictors of idiopathic asymmetry in infants born preterm. Nuysink, 2012[11]	Retrospective, longitudinal design. 192 infants	Inclusion: preterm infants, <32 weeks Exclusion: symptomatic asymmetry, central nervous system disorder, congenital	Cranial ultrasound examinations, asymmetry in posture and movement of head, developmental plagiocephaly, scaphocephaly, or brachycephaly. AIMS.	First visit at term-equivalent age, the second at 6 months corrected age.	None, retrospective study to identify predictors of idiopathic asymmetry.	At TEA prevalence rate of positional head preference was 44.8%, and 10.4% of infants had DP. At 6 months CA none had	At 6 months DP is observed in 13% of infants. In 5.2% the DP was resolved. Only chronic lung disease increased the odds of	Chronic lung disease was associated with development of DP in the premature stages of development.

		malformation, sensory system disorder.				a positional preference by 13% had DP. Chronic lung disease was significantly associated with positional preference with DP at TEA.	having DP at TEA but not at 6 months CA.	
Prevalence of positional plagiocephaly in teens born after the "Back to Sleep" campaign. Roby, 2012[12]	1045 children, ages 12-17	Not noted	Head circumference, oblique transcranial diameter, Cranial vault asymmetry (value greater than 1cm indicates plagiocephaly), cephalic index (greater than 0.90 indicates brachycephaly)	One time, cross-sectional measurement	None, cross-sectional analysis to determine the effect of the Back to sleep campaign on unresolved plagiocephaly	Positional plagiocephaly was 0.9% in girls and 1.6% boys, for an overall 1.1%. Brachycephaly was 0.8% in girls and 1.3% in boys, for an overall of 1.0%. Overall prevalence was 2.0%.	The prevalence was 2.0%, significantly lower than prevalence in infants, but greater than the prevalence prior to the 1992 Back to sleep campaign (0.3%)	If all infants dx with a deformational cranial abnormality are treated with helmeting, this could be overtreatment since the problem does not often persist into adulthood. Positioning has a major effect in prevalence, but changes and growing can help reduce the impact.
Infant position in	Systematic review of	Inclusion: term and	Oxygenation as measured by	Systematic review	Positioning in supine or prone	No clear evidence that	Prone offers a short term	There is benefit in mobility of

neonates receiving mechanical ventilation. Rivas-Fernandez 2016[13]	19 trials involving 516 participants.	preterm neonates requiring positive pressure MV or CPAP, placed in supine and compared with prone or lateral, and outcome measure related to oxygenation	PO2 or SpO2		or lateral	any position is effective in producing relevant and sustained improvement. However, infants who received ventilation in prone for a short time slightly improved levels of oxygen in the blood.	improvement in oxygenation, but long term no position is more beneficial than another	ventilated infants, since prone can produce short term improvements in oxygenation.
Head growth trajectory and neurodevelopmental outcomes in preterm neonates. Raghuram, 2017[14]	Retrospective cohort study. 1973 infants met the inclusion criteria	Inclusion: infants <29 weeks GA admitted to level III NICUs, who received follow-up assessments at 16-36 months Exclusion: infants with congenital or chromosomal anomalies, infants with palliative care, microcephaly, ventricular	Head circumference. HC Z score The difference between HC z scores at all three times were	At birth, discharge from NICU, and at follow-up assessment (corrected age noted at time of follow-up).	Retrospective study assessing characteristics associated with poor head growth during NICU stay and after NICU d/c.	Poor head growth (HG) was more frequent during infants NICU stay compared with post-dc. Infants with the poorest HG displayed the longest duration of mechanical ventilation and poorest weight gain during the NICU	Poor head growth, while multi-factorial, can be tied to extended stays in the NICU, time on mechanical ventilation. Neonates with the poorest HG also received more mechanical ventilation at all times.	Extended NICU stay, and particularly mechanical ventilation, is strongly correlated with poor head growth and poor weight gain in preterm infants.

		enlargement, hydrocephalus.				admission.		
Effects of Multiple Ventilation Courses and Duration of Mechanical Ventilation on Respiratory Outcomes in Extremely Low-Birth-Weight Infants. Jensen, 2015[15]	Retrospective cohort study of 3343 extremely low birth weight infants, 2867 survived to discharge.	Inclusion: infants weight less than 1000g, less than 32 wks GA, born from Jan 1 2006 to Dec 31 2012, intubated or received mechanical ventilation at least once during NICU stay. Exclusion: infants who died in delivery, infants who received surfactant without mechanical ventilation.	BPD (oxygen at 36 GA), death, continued supplemental oxygen use. # of distinct ventilation courses (as separated by 1 full day without MV)	From birth to NICU dc, duration of ventilation was treated as a continuous variable.	Duration of mechanical ventilation was a strong predictor of use of supplemental oxygen at NICU DC.	Long term, multiple courses of mechanical ventilation is common. The duration of mechanical ventilation was the strongest predictor of risk of BPD and of supplemental oxygen use at DC	The duration of mechanical ventilation was the strongest predictor of risk of BPD and of supplemental oxygen use at DC	Longer duration and multiple rounds of MV indicate continued use of MV, which may lead to further deformation of head and poor head growth.
Prolonged ventilation and postnatal growth of preterm	55 ventilated preterm infants	Inclusion: born less than 28 weeks, failed to stabilize with CPAP and had	Weight, head circumference, admission of corticosteroids, GA at birth, duration of	At birth and at discharge.	None, rather an assessment of weight gain and head growth in ventilated vs non-ventilated	The difference in weight z-score and HC z-score from birth to discharge was	Growth of extremely premature infants is significantly negatively	There is a significantly negative association between prolonged

infants. Williams, 2019[16]		to be intubated Exclusion: infants ventilated less than 7 days, transferred to another NICU, infants who died.	non-invasive mechanical ventilation.		infants.	significantly negatively related to the # of days on ventilation.	associated with weight gain, head growth, and general growth. Increase severity of respiratory illness is an increase in duration of mechanical ventilation.	ventilation and postnatal growth in extremely premature infants. This includes head circumference.

Impact of prolonged mechanical ventilation in very low birth weight infants: results from a national cohort study. Choi, 2018[17]	3248 very low birth weight infants born between January 1, 2013 and December 31, 2014	Inclusion: infants born weighing less than 1000g Exclusion: infants with congenital respiratory or cardiovascular anomalies, infants with incomplete data or who were transferred to other hospitals.	Outcome: Primary: survival to DC or death Secondary: BPD, pulmonary hypertension, ROP, PVL, abnormal AABR results, duration of hospital stay, duration of parenteral nutrition, Weight, height, and head circumference at birth and DC	Time Frame: Measured over duration of stay in NICU	Intervention: none, assessing effects of the following on growth: GA, cumulative duration of invasive mechanical ventilation, length of hospital stay	Results: Lower GA and birth weight were predisposing factors to prolonged mechanical ventilation. Longer durations of mechanical ventilation were associated with smaller Z scores for weight, height, and HC after adjusting for GA and weight. (Significant P)	Conclusions Prolonged exposure to mechanical ventilation is associated with multiple poor outcomes. Prolonged mechanical ventilation affected poor physical growth, including head circumferenc e.	Implications: mechanical ventilation is associated with poor health outcomes, and prolonged mechanical ventilation is negatively associated with proper head growth.

Growth in high risk infants <1500g birthweight during the first 5 weeks. Loui, 2008[18]	46 infants, 22 of whom were ventilated	Inclusion: birthweight <1500g Exclusion: death, leaving the hospital before day 35.	Weight gain, body length growth, head growth.	Daily for weight, weekly for length and HC.	Ventilation vs unventilated infants.	Ventilated infants had retarded growth and weight gain compared to unventilated infants. Head growth was 0.45 vs 0.60 cm/wk and lower than the typical infant avg of 0.90-1.04 cm/week	Duration of artificial ventilation was a predictor of weight gain and head growth.	Preterm and very underweight infants are already predisposed to retarded head growth. This increases with use of and increased duration of mechanical ventilation.

Long-term outcome of preterm infants with treated with continuous positive airway pressure. Wintermark, 2006[19]	117 infants admitted to the NICU	I: infants born at <1500g or <32 weeks, placed on nasal CPAP. E: genetic syndromes, congenital malformations, cerebral infection, transfer to other hospital, death.	Short term: ultrasonographic exam of brain, retinopathy maturity, auditory evoked responses. Long-term: development testing, growth	Duration of CPAP, 6 months corrected age, 18 months corrected age, age of 4.	Control: infants not on CPAP Intervention: CPAP at 5 cm H2O within 10-30 minutes.			Prolonged use of CPAP is associated with delays in physical growth and motor development.

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