Literature Summary on the Effects of CPAP on Preterm Infant Cranial Molding
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Abnormal cranial molding is a complex, multifaceted deformation commonly seen in premature infants. Wolff's law states that bones remodel according to the forces applied to them and this is especially true of infant cranial bones. At birth the cranial sutures, the joints between the bones, are not yet immobile and provide more ductility in the skull. Preterm infant bones have an extremely high rate of collagen which makes them increasingly malleable.[1] Premature infants are also more susceptible for acute respiratory distress and mechanical ventilation to stabilize oxygenation. During this time continuous positive airway pressure (CPAP) machines are used to provide continuous airflow and stabilize blood gas levels. These machines can apply pressures to certain areas of the cranium, resulting in abnormal cranial molding and poor head growth.[2,3] Positioning is commonly used by pediatric physical therapists as an intervention strategy to promote normal development and help with oxygenation. Positioning plays a key role in the improvement of oxygenation and in development of dolichocephaly. Dolichocephaly is defined as a boat-shaped or elongated anteroposterior axis of the head that occurs from skull flattening during side-to-side head positioning of the preterm infant during hospitalization.[4] Increased time spent in any one position can cause deformational pressures to the cranium, also resulting in abnormal infant cranial molding, and infants on CPAP are less likely to experience a variety of positions due to the tubing on the machine. As a result, cranial molding is impacted by the interplay of multiple factors on preterm infants in the NICU. The purpose of this review is to examine current evidence on the effect of these factors and their effects on cranial molding, particularly the development of dolichocephaly.

In preterm infants the use of CPAP machines can affect the frequency of position use and changes. Positioning has effects on both respiration and normal cranial development,[5-7] and is important to consider in the course of treatment for infants on CPAP. Studies support prone positioning as superior to supine for improving oxygenation and reducing apneic episodes in preterm infants receiving mechanical ventilation.[5,7,8] Oxygenation parameters such as SpO2 and FiO2 improve when infants are placed in the prone position.[9,10] In the case of preterm infants on CPAP, even alternating prone and supine for 2-4 hours at a time can provide short-term improvements in oxygenation and help stabilize respiration.[9] There is also a time dependent component to oxygenation that is associated with positioning.[9] Infants tend to stabilize and increase oxygenation parameters when left in prone for at least 2 hours.[7,8,10,11] This indicates that there are benefits in mobility for ventilated infants as the change in positioning can produce short-term improvements in oxygenation and increase ease of nursing care and procedures such as heel-sticks and suctioning. Evidence largely supports prone positioning for oxygenation and reducing the duration of mechanical ventilation and subsequent risk of cranial deformation.[7,8,10]

The use of CPAP machines alone is associated with poor head growth and abnormal cranial molding. Infants are more susceptible to cranial deformities due to gentle pressures over time than infants born at term. [12,13] This is due to the increased malleability to the neonate skull, weight of gravity, and often sustained supine positioning used for infants on CPAP.[13] Extended mechanical ventilation is strongly

associated with head growth and further deformation of the head. [12–14] This includes increased chances of development of dolichocephaly. If present at 32 to 34 weeks postmenstrual age, dolichocephaly has been linked to adverse motor outcomes including need for PT services following hospital discharge.[13] Adverse motor outcomes contribute to early motor delays, asymmetrical motor performance, and result in an increased need for outpatient physical therapy services. It is hypothesized that for successful treatment of dolichocephaly, systematic positional changes are needed to overcome the mechanical forces repetitive positioning places on head shaping of preterm and/or very low birth weight infants. [4,12-13] This is further complicated with the use of CPAP machines, which apply pressure to the cranium. To decrease the prevalence of dolichocephaly in preterm infants, direct positional change intervention is needed.[13,14] While integrating supine into a variable positioning regimen is recommended to limit the development of dolichocephaly, supine positioning is not ideal for developmental care and secondary conditions, such as respiratory distress.[4,15] Nuysink et al cites that if infants remain resting in supine, this can be predictive of asymmetric motor performance.[4,13] Persistent supine positioning puts undue pressure on the posterior skull and is counterintuitive for improving oxygenation. Therefore, future research should investigate optimal positioning protocols to prevent the development of dolichocephaly.

While a multitude of studies throughout the literature indicate the correlation between preterm or low birth weight delivery and the development of cranial molding deformities, these studies do not establish nor investigate a regimented positional protocol to prevent and/or treat cranial molding deformities.[4,15] Literature highlights the prevalence and implications of dolichocephaly; including the individual association between positioning, oxygenation, CPAP use, gestational age, and development of dolichocephaly. Further research is needed on positional change and positional protocols, to establish the best method for treating and preventing the development of dolichocephaly in the NICU.[4, 13]

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