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Chinstraps are Needed for Neonatal Nasal CPAP: Reflections from a Non-Human Primate Model

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To the Editor

Nasal continuous positive airway pressure (nCPAP) is the standard of care for non-invasive respiratory support of premature infants with respiratory distress syndrome, and often can be used instead of or following endotracheal intubation with mechanical ventilation. CPAP increases and stabilizes functional residual capacity by increasing the end-expiratory transpulmonary pressure. Effective nCPAP delivery requires snug-fitting nasal prongs, as well as a closed mouth to minimize the loss of distending pressure. The use of a chinstrap to keep the mouth closed is recommended in many neonatal intensive care units, but there is significant practice variation among nurseries, ranging from always using chinstraps, rarely using chin straps, or only using a chinstrap when there is an obvious leak at the mouth (1,2). During nCPAP use in neonates, it has been demonstrated that hypopharyngeal pressure is much higher with the mouth actively closed compared to the mouth in a passive position (3) and that oropharyngeal pressures increase when the mouth is closed around a pacifier compared to being open (4). A study of 32 neonates demonstrated no significant influence of mouth opening on oxygen saturation or respiratory rate, but concluded that the effect of mouth leaks during nCPAP should be further studied (5). These observations suggests that actively closing the mouth, such as by using a chinstrap, will reduce air leak at the mouth, and potentially increase lung distending pressure; however, this latter effect has not been documented.

In our study evaluating the effects of nCPAP on lung growth of premature non-human primates (NHP: rhesus macaque), we also examined the effect of using the chinstrap upon

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the effective delivery of transpulmonary pressure in sedated primates. Studies were approved by the Oregon National Primate Research Center Institutional Animal Care and Use Committee. Timed rhesus macaque pregnancies were treated with betamethasone 48- and 24- hours prior to scheduled Cesarean section at day 140 of gestation (85% gestation, 32–34 week human equivalent). Twenty-four hours after birth, bubble nCPAP was applied using a Babi-Plus™ CPAP jar (A Plus Medical, Carlsbad, CA 92008, U.S.A) and Hudson RCI (Morrisville, NC 27560), nasal prongs (size 0,10 French) modified to fit the shape and size of the preterm rhesus macaque nares, and a chinstrap made from soft tubular elastic stretch net (Owens and Minor, Richmond VA, 23261) placed over the chin to keep the infant's mouth closed at rest. Esophageal pressure (Pes) was measured as an estimate of pleural pressure, using a catheter passed orally (Millar™ 2Fr micro-transducer). The applied proximal airway opening pressure (Pao) generated by bubble CPAP was measured at the elbow of the nasal prong on the inspiratory limb of the circuit (MLT0699 pressure transducer). The effective lung distending pressure or transpulmonary pressure (Ptp) was calculated as Pao – Pes. Data was digitized (AD Instruments, Colorado Springs CO 80906), recorded, and analyzed using PowerLab™ and LabChart™ software. Animals were evaluated under moderate-deep sedation (intravenous ketamine: 5 mg/kg PRN or continuous intravenous infusion of clonidine: 2.5–3.5 mcg/kg/hour). For each of 12 animals, 15-second measurements were recorded during spontaneous tidal breathing under three sequential conditions: A) Chinstrap-On, B) Chinstrap-Off by detaching one side of the Velcro™, and C) Chinstrap-On, re-attached. For each animal, the mean Ptp was calculated for recordings obtained under (A), (B), and (C) conditions. Using the starting condition of (A) as a reference, the values for (B) and (C) were expressed as a percentage of A. Paired t-tests were used to evaluate differences between conditions to determine whether the group mean percentages of (B) and (C) were significantly different from each other, as well as from the references value of 100%.

Figure 1 illustrates the comparisons between the different conditions. The Chinstrap-OFF condition (B) decreased Ptp to a mean of 79 ± 4 % compared to the initial Chinstrap-On condition (A). Following reapplication of Chinstrap-On condition (C), the group mean Ptp was 103 ± 5%, which was significantly higher than Chinstrap-OFF condition (B) ($p=0.0047$), but not significantly different from the initial Chinstrap-On condition (A) (p-value=0.57).

Our observations demonstrate that the application of a chinstrap during nCPAP therapy results in more than a 20% increase the lung distending pressure compared to when the mouth is visually closed, but without the chinstrap. An open mouth results in loss of almost all of the distending pressure; however, visual observation of mouth closure is not adequate to deliver the prescribed distending pressure, even if bubbling is still observed in the water of the CPAP jar. As the purpose of CPAP treatment is to increase lung distending pressure, our findings strongly support always using chin-straps. A limitation to our study is that the NHP infants required sedation to facilitate nCPAP administration, as these late preterm NHP infants had considerable grasp strength at birth, which would otherwise result in their pulling off the nCPAP. In contrast, human infants on nCPAP rarely require sedation and can be more active. Therefore, for more active human infants without sedation, not using a chinstrap may result in an even greater pressure loss at the mouth and loss of lung distending pressure. This

study was not designed to assess the possible side effects of leak reduction such as pneumothoraces and did not asses the effects on carbon dioxide elimination. In addition, our later term NHP infants had relatively mild respiratory disease and required a relatively low degree of respiratory support. For infants with more severe respiratory disease with less compliant lungs that may even require higher nCPAP pressures, it is anticipated that not using a chinstrap may result in an even greater leak at the mouth and an even greater loss of lung distending pressure. It is not clear that the 20% decrease in Ptp has an effect on long term clinical outcomes, which would require further clinical trials. In summary, our findings suggest that to maximize delivery of prescribed nCPAP therapy, the current recommendations to use a chin strap should be followed even when the mouth appears closed and bubbling persists in the CPAP jar.

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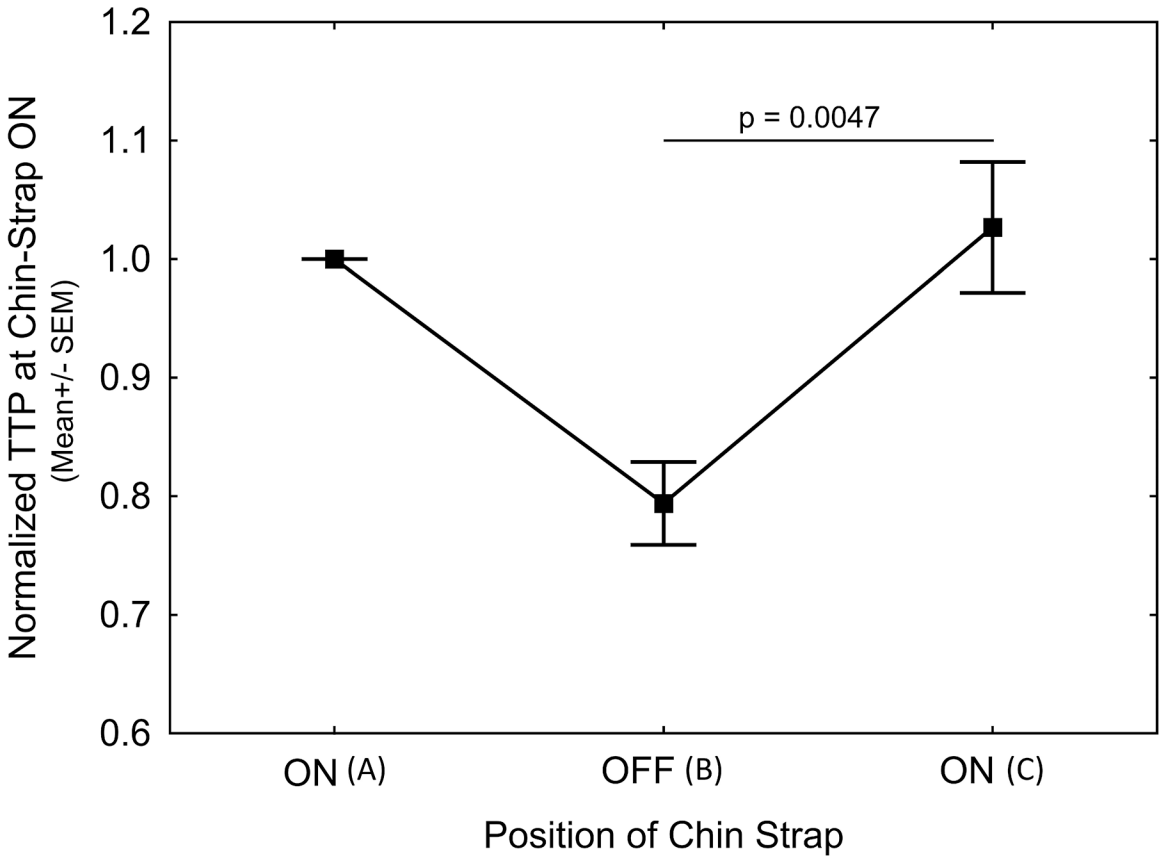

Figure 1.

Group (N=12) mean ± SEM of transpulmonary Pressure (Ptp) measurements obtained with Chinstrap Off (B) and Chinstrap ON - reapplied (C) expressed as a percentage of the Ptp measured at baseline with Chinstrap On (A).