Effects of nasogastric tube placement, head position and nostril choice on episodes of apnea, bradycardia and desaturations in the preterm neonate

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2016

Dedication

I am dedicating my project to my husband, Justin, and my best friend, Tiffany. This past year has been challenging on every level and they have been my support throughout it all. I would not have made it through this year without them.

Acknowledgements

I would like to thank Dr. Howard Stein for his time, dedications, and mentorship during the course of this project. He has been there to direct me and answer questions throughout the whole process. He spent hours in the NICU recruiting participants and instructing the nurses on charting. This project would not have been possible (and definitely would not have gone as smoothly) without him. Dr. Stein, I am very grateful that you agreed to be my advisor!

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Introduction

Apnea of prematurity is a common diagnosis for preterm neonates, especially those in the Neonatal Intensive Care Unit (NICU), and the severity is inversely correlated with gestational age (Eichenwald & AAP Committee on Fetus and Newborn, 2016). The combination of inflammation, immature lung development, immature respiratory control, low functional residual capacity with low oxygen reserves, highly compliant upper airway and chest wall, and altered central and peripheral chemoreceptor activity leads to episodes of apnea resulting in hypoxia in the preterm neonate. As the frequency of apnea, bradycardia, and desaturation (ABD) episodes increases, the neonate's risk of retinopathy of prematurity and negative neurodevelopmental outcomes also increase (Di Fiore, Martin, & Gouda, 2013). Preterm neonates have difficulty feeding, due to their inability to coordinate sucking and swallowing and therefore, enteral feedings are often needed (Symington, Ballantyne, Pinelli & Stevens, 1995). Use of a nasogastric tube (NGT) causes a significant increase in airway resistance during the time an NGT is in place. Placing the NGT in the larger nostril causes a larger increase in nasal and airway resistance than when placed in the smaller nostril. This difference is more pronounced in white compared to black neonates (Stocks, 1980). Head position effects nasal airflow in neonates with and without a NGT. Nasal airflow is impeded most when the NGT is in the upper nostril when the neonate is supine with head turned (Martin, Siner, Carlo, Lough, and Miller, 1987).

It has been determined that although NGTs are often medically necessary for the neonate in the NICU, they affect a neonate's breathing as they are obligate nose breathers, NGTs can be considered an obstruction in one nasopharynx (Stocks, 1980). Although it is known that NGTs affect a preterm neonate's nasal airflow and that the effect is exasperated when the neonate's

head is lateral with the NGT in the upper nostril (Martin et al., 1987), it is unknown whether the NGT in the upper or lower nostril affects the number of ABD episodes experienced.

The purpose of this research is to identify if NGT placement and head position affect the number of ABD episodes that preterm neonates experience. The majority of preterm neonates in the NICU require NGTs or OGTs for feeding and these tubes likely increase the number of apneic episodes. Although tube feeding cannot be avoided for many of the NICU neonates, this research may further direct clinical practice to minimize periods of apnea and the possible detrimental effects of apnea.

The hypothesis is that neonates will experience a greater number of ABD episodes when the NGT is in the upper nostril vs. the lower nostril or midline, regardless of body position (supine versus prone versus sidelying).

Literature Review

Stocks (1980) looked at the long and short-term effects of nasogastric tube (NGT) use on nasal and airway resistance in preterm (30-36 weeks) neonates. The study found that use of an NGT caused a significant increase in airway resistance during the time the NGT was in place. Results indicated that placing the NGT in the larger nostril caused a larger increase in nasal and airway resistance (138% white, 97% black) than when placed in the smaller nostril (101% white, 50% black). Stock also found that nasal resistance was significantly lower in black neonates than white neonates both at rest and with a NGT in place. Stock suggests that this result was due to obstruction of the larger nostril by the NGT, therefore forcing the neonate to breathe through the smaller nostril, which has higher resistance due to its diameter. The effect of the nasogastric tube on total airway resistance had less than 50% increase when the NGT was in the larger nostril and 32% when in the smaller nostril. Based on the findings of her study, Stock recommended use of the smallest diameter NGT possible, placed in the smaller nostril.

Martin, Siner, Carlo, Lough, and Miller (1987) conducted a study on twelve preterm neonates (32-36 weeks) to evaluate the effect of head position on nasal airflow with and without an NGT in place. Without an NGT, turning of the head to the right or left when supine caused the percent of total tidal volume ($\%V_T$) to decrease through the upper nostril (52% to 43%) and increase through the lower nostril (52% to 67%) when compared to midline values. With an NGT in one nostril, the $\%V_T$ decreased from 54% to 39% through the nostril with the NGT when the head was midline. Turning the head so that the side with the NGT was up caused the $\%V_T$ of that nostril to decrease further to 25%, while turning the head so that the side with the NGT was down caused the $\%V_T$ of that nostril to return to the midline value (54%). Martin et al. concluded

that nasal airflow is impeded most when the NGT is in the upper nostril when the neonate is supine with head turned.

Summary –	%	TV % change
Head midline – no NG	54%	
with NG tube	54% to 39%	-28%
Head turned side:		
Upper nostril – no NG	52% to 43%	-17%
with NG from midline	39% to 25%	-36%
with NG from side	43% to 25%	-42%
Lower Nostril – no NG	52% to 67%	+29%
with NG from midline	39% to 54%	+38%

Symington, Ballantyne, Pinelli, and Stevens (1993) performed a study on eighty-four preterm neonates (24-34 weeks) to evaluate the effects of indwelling NGT placement versus intermittent OGT placement on weight gain, apnea, and bradycardia. The authors calculated the mean number of apneic and bradycardic events for each group and then used a t-test to determine that there was no statistically significant difference between the two groups. Based on the results, Symington et al. suggest that the effects of indwelling NGTs and intermittent OGTs are similar and therefore cannot guide clinical practice.

Bohnhorst, Cech, Peter, and Doerdelmann (2010) conducted a study of 32 NICU neonates to evaluate the effects of OGT versus NGT on apnea of prematurity, specifically the effects on bradycardia and hypoxemia. The authors measured and recorded the number of desaturations and bradycardias, as well as the duration of desaturation episodes, and the lowest value reached for both parameters. The study found that there were no statistically significant

differences between the effects of NGT and OGT placement on episodes of apnea, bradycardia, and desaturation.

Greenspan, Wolfson, Holt, and Shaffer (1990) assessed the acute effects of NGT and OGT on pulmonary function in 24 respiratory-stable neonates as a function of infant weight (14 infants weighing < 2 Kg and 10 infants weighing > 2 Kg). Neonates weighing <2 Kg demonstrated diminished minute ventilation and respiratory rate and increased pulmonary resistance, resistive work of breathing and peak transpulmonary pressure with NGT, as compared to OGT. The infants with a weight of > 2 Kg demonstrated no change in pulmonary function with nasal versus oral placement of the tube. Otherwise, no infants had apparent clinical compromise with NGT or OGT placement. This finding supports the assumption that application of NGT may increase the work of breathing just in very low birthweight neonates, but that this only becomes clinically evident after a prolonged period of time.

A review by Bredemeyer and Foster (2012) attempted to determine the effects of various positions on episodes of apnea, bradycardia, and oxygen desaturation in preterm neonates. No significant differences were found among the studies used for the effects of supine versus prone, prone versus right lateral, prone versus left lateral, right lateral versus left lateral, prone horizontal versus prone head elevated, right lateral horizontal versus right lateral head elevated, or left lateral horizontal versus left lateral head elevated positions. However, none of the included studies evaluated the other positions (supine versus right lateral, supine versus left lateral, or supine horizontal versus supine elevated). The authors concluded that there is inadequate research on this topic, and they did not evaluate the effects of body versus head position.

Watson and McGuire (2013) performed a review of the literature regarding OGT versus NGT placement in premature neonates. One of the secondary outcomes studied in the review included the effect of OGT versus NGT placement on episodes of apnea. Of the studies included, one found that the NGT group had significantly more episodes of apnea compared to the OGT group, while one study found no significant difference, and the third study did not measure episodes of apnea. Overall, McGuire concluded that there is insufficient evidence to determine if OGT or NGT placement effects episodes of apnea in the preterm neonate.

In 2013, Di Fiore, Martin, and Gauda performed a review on the pathophysiology, diagnostic assessment, and therapeutic interventions of apnea of prematurity. The review gives a standard definition of apnea of prematurity and the three major types: obstructive, central, and mixed. The authors describe how the combination of inflammation, immature lung development, immature respiratory control, low functional residual capacity and low oxygen reserves, highly compliant upper airway and chest wall, and altered central and peripheral chemoreceptor activity leads to episodes of apnea resulting in hypoxia in the preterm neonate.

Corvaglia et al. (2014) conducted a study of thirty-three preterm neonates (< 33 weeks) to measure the effects of bolus versus continuous OGT feeding on cardiorespiratory parameters. The results showed that continuous feeding caused more apneas and hypoxic episodes. The study did find that bolus feeding caused more periods of bradycardia directly after administration, however, this finding was not statistically significant.

Di Fiore, Poets, Gauda, Martin, and MacFarlane (2016) conducted a review to explain lung development and pathophysiology as it pertains to cardiorespiratory events, particularly apnea, bradycardia, and intermittent hypoxia. The article walks the reader through the stages of lung development and the various respiratory control mechanisms, showing how preterm birth

leads to immature and dysfunctional lungs and respiratory control, which in the setting of inflammation can cause significant cardiorespiratory events.

Eichenwald and the AAP Committee on Fetus and Newborn (2016) presents an up to date review focusing on apnea of prematurity, including its definition, epidemiology, and treatment. The review discusses the three major types of apnea (central, obstructive, and mixed) and explains the various clinical techniques used to measure changes in heart rate and oxygen saturation caused by episodes of apnea, with special attention to areas needing improvement in order to better treat preterm neonates with apnea of prematurity. The significance of being able to adequately treat apnea of prematurity is shown by the fact that nearly all neonates born before twenty-eight weeks' gestation are diagnosed with apnea and the majority of neonates born at or before thirty-five weeks' gestation need cardiorespiratory monitoring.

Mase et al. (2016) conducted a study of eight adults to determine the effects of different positions (supine, side-lying, semi-prone) on lung function. They found that there was greater compression on the lungs by the heart when side-lying compared to when semi-prone. They also found that when side-lying, although there is increased ventilation of the non-dependent lung, there is decreased expansion and ventilation of the dependent lung.

Methods

The study design was a prospective observational study. The population of interest is preterm infants in the NICU at Toledo Children's Hospital off all respiratory support, on feeds (may still need IV), still requiring all or some of their feeds by NGT and having ABD episodes. The sample will be selected via simple random sampling of eligible NICU infants. Informed consent will be obtained. Neonates on any respiratory support or with orogastric tubes will be excluded.

Nurses routinely record each ABD episode and the presence of a NGT. In addition, they will also record body and head position, NGT sidedness for each ABD episode. This data and demographic data to include gender, race, birth weight, weight at time of study, gestational age, age at time of study, major diagnosis. The dependent variables will be body position (supine vs prone vs sidelying), NGT placement (upper vs lower vs midline). The independent variable will be ABD episodes.

Data collection sheets will be at the bedside of enrolled babies. Nurses will record the details of each ABD episode after they occur. The data collection sheets will be returned to the study investigator when full or when the baby is no longer having ABD episodes.

The data will be analyzed using a 2-sample z-test for percentages in order to determine if there is a statistically significant difference in the number of ABD episodes in preterm infants comparing NG tube placement and body position.

Results

There were 32 neonates enrolled in the study. Three neonates had no spells before leaving the NICU and two went home on oxygen. Therefore, data was collected on 27 neonates. 74% of the neonates were born via caesarean section and 26% were born via vaginal delivery. The reasons for delivery of the neonates were 59% preterm labor, 33% pregnancy induced hypertension, 15% premature rupture of membranes, 7% HELLP, 7% twin-to-twin transfusion syndrome, 3% maternal Influenza B, and 3% gestational diabetes. The median one-minute APGAR score of the neonates was 6 and the median five-minute APGAR score was 8. 74% of the neonates received maternal steroids. 59% of the neonates required surfactant. 67% of the neonates were female; 96% were Caucasian. The diagnoses at time of birth include 67% respiratory distress syndrome, 22% transient tachypnea of the newborn, and 11% apnea of prematurity.

The average birth weight of neonates in the study was 1463.6 grams $\pm$ 419.7 grams. The average gestational age was 30.4 weeks $\pm$ 2.7 weeks. Neonates were eligible to enter the study when off all respiratory support. The average weight upon entering the study was 1651.7 grams $\pm$ 324.7 grams. The average age upon entering the study was 21.1 days $\pm$ 17.7 days. The average number of ABD episodes per baby during the study was 39.5 spells $\pm$ 31.5 spells.

Figure 1 shows the number of ABD episodes with NG tube placement. 38% of the total number of ABD episodes occurred when the NG tube was in the upper nostril, 34% in the lower nostril, and 28% when midline. There were more ABD episodes with the NG tube in the upper nostril versus midline ($p=0.006$). More ABD episodes that required stimulation occurred with NG tube midline compared to the upper ($p=0.0001$) or lower ($p=0.008$) nostrils. Bradycardia (heart rate $\leq$ 80 bpm) occurred equally in all NG tube positions. However, severe bradycardia

(heart rate $\leq$ 60 bpm) occurred more often in the lower nostril compared to midline ($p = 0.004$). There were no differences in desaturations or apnea between all NG tube positions.

As shown in Figure 2, when both prone and sidelying there were less ABD episodes with the NG tube midline compared to both in the upper ($p=0.04$ prone and $p<0.0001$ sidelying) and in the lower (p=** prone and $p=0.004$ sidelying) nostril placement of the NG tube. When supine, there were more ABD episodes with the NG midline compared to both in the upper ($p<0.0001$) and lower ($p<0.0001$) nostrils.

Figure 3 shows the total ABD episodes in various body positions and how the positions relate to the type of ABD episodes. 12.7% of total ABD episodes occurred when the neonates were prone, 35.9% when supine, and 51.4% when sidelying. There were more ABD episodes when positioned sidelying compared to both prone ($p<0.0001$) and supine ($p<0.0001$) and more ABD episodes when positioned prone versus supine ($p<0.0001$). More ABD episodes required stimulation to recover in the supine versus sidelying positions ($p = 0.004$). The number of bradycardic events (heart rate $\leq$ 80 bpm) that occurred when supine versus prone ($p = 0.049$) and sidelying ($p = 0.016$). Severe bradycardia (heart rate $\leq$ 60 bpm) occurred less when supine versus sidelying ($p = 0.016$). Desaturation (saturation $\leq$ 87%) occurred less when supine versus prone ($p = 0.001$) or sidelying ($p = 0.007$). Mild desaturation (saturation 41% – 60%) equally in all positions. Severe desaturation (saturation $\leq$ 40%) occurred less when supine versus sidelying ($p = 0.006$). Apnea occurred mostly in prone versus supine ($p=0.009$) and sidelying positions ($p=0.005$).

Discussion

This study looked at the number of ABD episodes in neonates in relation to NG tube and body position. These ABD episodes were then further analyzed to the type and severity of episode in relation to NG tube placement and body position.

Most ABD episodes occurred when the NG tube was in the upper nostril, and the least number of total ABD episodes occurred when the NG tube was midline. This could be explained by the NG tube partially obstructing the nostrils and decreasing effective tidal volume. This is consistent with the study by Martin et al. (1987) who found that, although midline placement of an NG tube decreased the tidal volume, this was further decreased when the head was turned so that the NG tube was in the upper nostril. When the NG tube was in the lower nostril, the tidal volume returned to the midline value. It is not surprising this would be worst with the NG tube in the upper nostril because of obstruction of the upper nostril by the NG tube and the pressure placed on the lower nostril.

However, stimulation was needed most commonly when the NG tube was midline. The reasoning for this result is unclear. Bradycardia occurred more often when the NG tube was in the upper nostril, but severe bradycardia was most common when the NG tube was in the lower nostril. Desaturations tended to occur when the NG tube was in the lower nostril, however, mild desaturations occurred more commonly when the NG tube was in the lower nostril or midline, and severe desaturations occurred more commonly when the NG tube was in the lower or upper nostrils. Apnea was most common when the NG tube was in the lower nostril. Based on our results, the best position for the NG tube in order to minimize the number and severity of spells is midline. This finding is consistent with the results of Martin et al. (1987).

When looking at the total number of ABD episodes and body position alone, we found that there was a significant difference between the number of ABD episodes that occurred in each position. The largest number of ABD episodes occurred when the neonates were sidelying, then supine, and the least when prone. Being in the sidelying position may increase the incidence of ABD episodes for neonates due to the decreased compliance and expansion of the dependent lung (Mase et al., 2016).

When we assessed NG tube position and body position, we found that when neonates were prone or sidelying the majority of spells occurred when the NG tube was in the upper nostril. However, when supine, the significant majority of spells occurred with the NG tube midline. As found in the study performed by Martin et al (1987), the tidal volume is notably decreased when the NG tube is in the upper nostril and this likely accounts for the large number of spells that occurred when the NG tube was in the upper nostril. When neonates are supine, the most natural head position may be midline therefore accounting for the majority of spells occurring with the NG tube midline.

The need for stimulation and occurrence of bradycardia was most common when neonates were supine. Severe bradycardia was more common when neonates were sidelying. Desaturations most commonly occurred when neonates were prone, but mild and severe desaturations occurred more often when neonates were sidelying. Apnea was most common when neonates were prone. Sidelying appears to be the body position that corresponds with the largest number of spells and the most severe spells. This coincides with the well-known relationship between sidelying and an increased risk of Sudden Infant Death Syndrome (Colvin, Collie-Akers, Schunn, Moon, 2014). Although the reason for this relationship remains unclear.

Limitations

Stocks (1980) found that there was a significant difference in nostril airway resistance between white and black neonates, however, we were unable to investigate the effects of race on NG tube placement and ABD episodes due to the majority of our random population being white.

Bohnhorst, Cech, Peter, and Doerdelmann (2010) found that there was no statistically significant difference between the effects of NG tubes and OG tubes on ABD episodes in neonates. Watson and McQuire (2013) conducted a review and determined that there was insufficient evidence on this topic. We did not include neonates with OG tubes, but this would be an important area for future research.

In 2014, Corvaglia et al. (2014) explored the effects of continuous versus bolus OG tube feedings on apnea and hypoxia in neonates. They found that continuous feeding lead to more apneic and hypoxic episodes. We did not include continuous versus bolus feedings in our variables.

Relevance to the PA Profession

Physician assistants care for patients in many settings with a variety of diagnoses. It is common for PAs to be managing patients, adults and children, needing enteral feeding with an NG tube and therefore this research can guide practice to prevent adverse cardiorespiratory events in patients with NG tubes.

Conclusion

The purpose of this research was to determine if NG tube placement and body position affect the number of ABD spells experienced by neonates in the NICU. We confirmed our hypothesis that regardless of body position, the majority of spells would occur when the NG tube was in the upper nostril, except when neonates were supine. Based on the results of our study, the best position for neonates is supine with the NG tube midline in order to reduce the number and severity of ABD spells.

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Figures

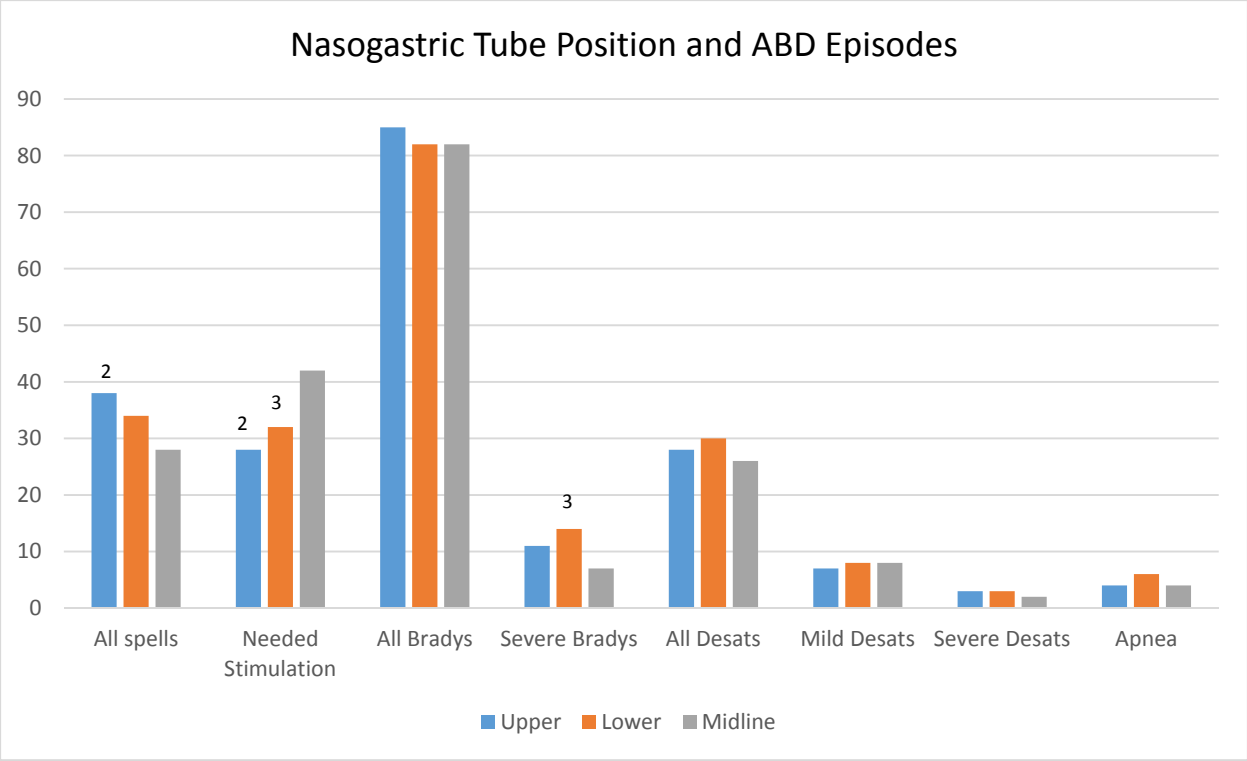

Figure 1: NG tube position versus type of ABD episodes. 1 = $p<0.05$ upper vs. midline, 2 = $p<0.05$ lower vs. midline

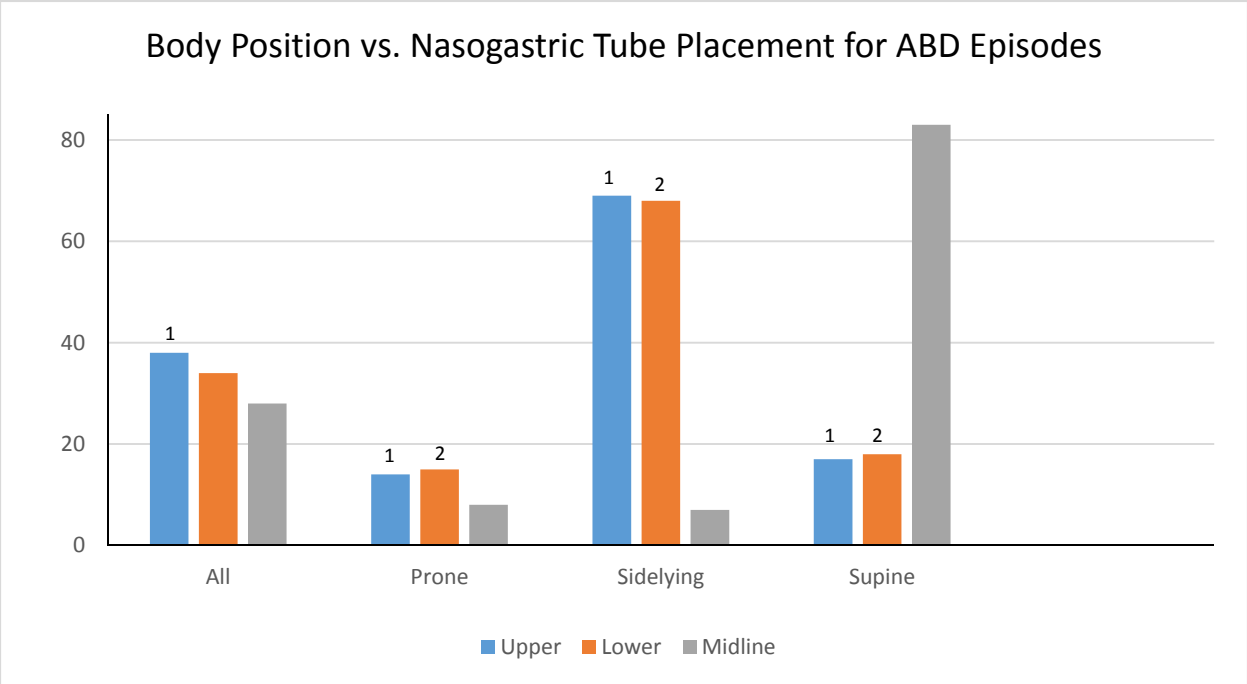

Figure 2: Distribution of the ABD episodes overall and in various body positions. 1 = $p<0.05$ upper vs. midline, 2 = $p<0.05$ lower vs. midline

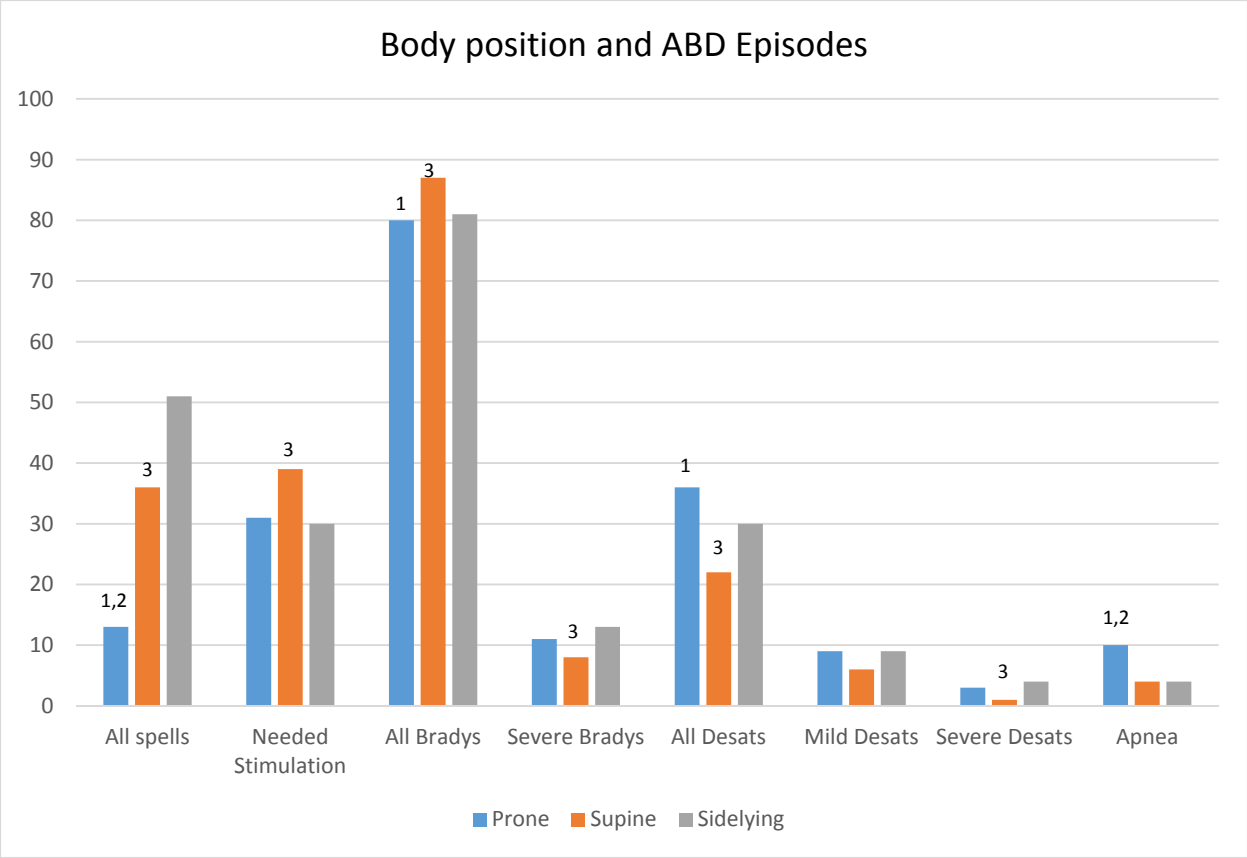

Figure 3: Body position versus type of ABD episodes. 1 = $p<0.05$ upper vs. lower, 2 = $p<0.05$ upper vs. midline, 3 = $p<0.05$ lower vs. midline.

Abstract

Preterm infants commonly require nasogastric tubes (NGT) which cause a significant increase in airway resistance likely increasing the number of apneic, bradycardic, and desaturation episodes. Head position also effects nasal airflow. The purpose of this research is to identify the effect of NGT placement and head position on ABD episodes in preterm neonates. This is a prospective observational study of preterm infants in the NICU at Toledo Children's Hospital off all respiratory support and requiring an NGT. Most ABD episodes occurred with the NGT in the upper nostril, and the least occurred with the NGT midline. When neonates were prone or sidelying the majority of spells occurred when the NGT was in the upper nostril. When supine, the significant majority of spells occurred with the NGT midline. Based on the results of our study, the best position for neonates is supine with the NG tube midline in order to reduce the number and severity of ABD spells.