Research Article / Araştırma Makalesi

The Effect of Two Different Nasal Interfaces Used in Post-Extubation Non-Invasive Respiratory Support on Extubation Success in Newborns

Yenidoğanlarda Ekstübasyon Sonrası Non-İnvaziv Solunum Desteğinde Kullanılan İki Farklı Nazal Arayüzün Ekstübasyon Başarısına Etkisi

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Abstract

Background: Non-invasive ventilation support is frequently used in newborns after extubation. The efficiency of non-invasive ventilation support is associated to type of nasal interface used. We aimed to investigate the effect of nasal interface type in our study on extubation success.
Materials and Methods: We retrospectively evaluated a total of 105 term and preterm patients who were extubated to non-invasive ventilation. We divided the patients into two groups according to nasal interface type: RAM cannula or short binasal prongs (SBPs). We examined extubation failure between the two groups.
Results: While 63 of the patients were in RAM cannula group, 42 of them were in SBPs group, and the demographic characteristics of the patients were similar. There was no statistically significant difference in the extubation failure rates between the groups (RAM; %44.4 vs SBPs; %38.1, *p*=0.518). The Ram cannula group had a higher beginning median positive end-expiratory pressure value (7.0 vs 6.5 cmH2O, *p*=0.038; respectively) and a lower median respiratory rate (60 vs 62/minute, *p*=0.032; respectively) than the SBPs group.
Conclusions: We believe that the easy-to-use RAM cannula can be used in selected patients, especially by setting the PEEP value approximately 1 cmH2O higher.

Key Words: RAM cannula, Short binasal prongs, Nasal interface, Extubation success, Non-invasive ventilation

Öz

Amaç: Yenidoğanlarda ekstübasyon sonrası non-invaziv ventilasyon desteği sıklıkla kullanılmaktadır. Non-invaziv ventilasyon desteğinin etkinliği, kullanılan nazal arayüzün tipiyle ilişkilidir. Çalışmamızda nazal arayüz tipinin ekstübasyon başarısına etkisini araştırmayı amaçladık.
Materyal ve Metod: Non-invaziv ventilasyona ekstübe edilen toplam 105 term ve preterm hastayı retrospektif olarak değerlendirdik. Hastaları, kullanılan nazal arayüz tipine gore; RAM kanül veya kısa binazal prong (KBP) olarak iki gruba ayırdık. İki grup arasındaki ekstübasyon başarısızlığını inceledik.
Bulgular: Hastaların 63'ü RAM kanül grubunda, 42'si KBP grubunda olup hastaların demografik özellikleri benzerdi. Gruplar arasında ekstübasyon başarısızlık oranları açısından istatistiksel olarak anlamlı fark yoktu (RAM; %44.4 vs KBP; %38.1, *p*=0.518). RAM kanül grubu KBP grubuna gore; daha yüksek başlangıç ortanca pozitif ekspirasyon sonu basınç (positive end expiratory pressure=PEEP) değerine (7.0 ve 6.5 cmH2O, *p*=0.038; sırasıyla) ve daha düşük ortanca solunum hızına (60 ve 62/dakika, *p*=0.032; sırasıyla) sahipti.
Sonuç: Kullanımı daha kolay RAM kanülünün seçilmiş hastalarda özellikle PEEP değerinin yaklaşık olarak 1 cmH2O daha yüksek ayarlanmasıyla kullanılabileceğini düşünüyoruz.

Anahtar Kelimeler: RAM kanül, Kısa binazal prong, Nazal arayüz, Ekstübasyon başarısı, Non-invaziv ventilasyon

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Introduction

Although mechanical ventilation and intubation are life-saving procedures for neonates suffering respiratory distress; they may cause adverse effectsin long-term, such as bronchopulmonary dysplasia, sepsis, neurologic impairment, and retinopathy of prematurity (1, 2). In order to protect intubated patients from these risks, extubation should be aimed as soon as possible. Since two-thirds of infants born before 29 weeks of pregnancy require extubation, physicians should be well-versed in mechanical ventilation methods and successful extubation strategies (3). Metilxanthines, using steroids, post-extubation non-invasive respiratory support are the strategies which increase the success of extubation (4-6).

Non-invasive ventilation (NIV) provides positive pressure respiratory support without intubation to patients who have sufficient respiratory effort by using various nasal interfaces. NIV can be used in a multiple of ways, including nasal continuous positive airway pressure (nCPAP) and nasal intermittan positive-pressure ventilation (NIPPV). NCPAP has been successfully implemented for more than 40 years (7). According to the meta-analysis, implementing NIPPV after extubation reduces re-entubation, surfactant requirement and airleakages compared to NCPAP (8). Although the types of interfaces used vary between unites, short binasal prongs (SBPs) and nasal masks are the most common (9, 10). The type of interfaces used may influence the success of extubation by affecting effective delivery of adjusted pressure to the lungs (11).

RAM cannulas are becoming more common in neonatal units because they are more comfortable for patients, connect directly to all mechanical ventilator circuitries, are easily bindable and have a practical design. Furthermore, the RAM cannula has been approved for nasal oxygen treatment, but there has not been enough research on its use as a NIV interface. In this study, we aimedto evaluate the effects of two different nasal interfaces which are used in post-extubation non-invasive respiratory support (RAM cannula, SBPs) on extubation success.

Materials and Methods

Our study was conducted after approval by İnönü University Non-Interventional Clinical Research Ethics Committee (number: 2021/ 1618). We conducted our study by retrospectively examining the files of patients hospitalized in our neonatal intensive care unit between January 1, 2019 and December 31, 2020. In our unit, all intubated patients are extubated as soon as they are fit to be. Extubation to nasal respiratory support that is a successful extubation strategies is preffered in all patients.The study included patients who had been intubated for at least 12 hours and then extubated to NIPPV mood non-invasive ventilation. Patients who had not been extubated to NIV and had received sedation within the last 24 hours before extubation, as well as those with severe central nervous system anomalies and congenital heart defects, were not include to the study. Patients who had developed cardiac arrest within 72 hours after extubation and had to be reintubated for surgery were excluded from the study.

Initial ventilation values and vital signs with the changes done afterward, the used value offraction of inspired oxygen (FiO2), andoxygen saturation values watched by pulse oximeter of the patients receiving invasive and NIV support in our unit are recorded under nurse observation. Core clinic data (the indication of intubation, intubation duration, extubation time and NIV cannula type) and demographic data (gender, birth weight, gestational age, mode of delivery) of the patients were obtained from the patients' folders. In addition, pre-extubation mechanical ventilator pressure values and oxygen necessities, pro-extubation NIV pressure values and blood gas measurements were recorded. Patients were divided into two groups according to the type of nasal interface used after extubation as RAM cannula (NeoTech TM, Valencia, CA) and SBPs (Hudson Respiratory CareInc, Temecula,CA and easy Flow nCPAP systems, Stephan, Germany or Easy Flow bi-nasal prong Fritz Stephan GmbHGackenbach Germany) The patients who were re-intubated in the 72 hours after extubation were acceptedas extubation failure.

Non-invasive Extubation Protocol

Almost all of our intubated patients in our unit receive NIV support in the mode of NIPPV to reduce the frequency of re-intubation after they are extubated when they no longer need intubation. While the patients were monitored in synchronized intermittent mandatory pressure mode, while the respiratory rates were reduced to 30 in a minute and their FiO2 needs were below 0.30 they were extubated if their oxygen saturation ranges were above 90%-95%. NIV support is provided with pressure controlled conventional neonatal ventilator. Patients are getting NIV support with RAM cannula or SBPs according to the appropriateness of ventilator and the choice of responsible physicians. In our clinic, initial NIPPV values are as follows; positive end-expiratory pressure (PEEP) as 5-8 cmH2O, peak inspiratory pressure (PIP) as 15-20 cmH2O, respiratory rate as 20-30 in a minute, inspiration time as 0.4 seconds and FiO2 as 0.21-0.50 depending to the aimed oxygen saturation range (90%-95%). These settings are then adjusting according to the patients' clinical situation, chest radiography and blood gas values. Except for uncommon conditions, venous or capillary blood gas analysis is used. During follow-up, patients are gradually decompressed and weaned from nasal respiratory support. This procedure differs depending on the patient's clinic.

The patients who are re-intubated in our clinic in general as following: Patients with clinical signs of severe respiratory distress with NIV support and appropriate PEEP, patients with a PCO2 value above 60 mmHg, patients with persistent FiO2 requirement of more than 0.50 to reach target oxygen saturation level, patients experiencing frequent episodes of

apnea or needing positive pressure ventilation more than twice a day.

Statistical Analysis

Statistical analysis was performed using SPSS version 21.0 software. Shapiro Wilk test was used in the eligibility check of continuous variables to normal distribution. Independent student t test was used in the normally distributed variables' 2 independent groups comparison. Mann Whitney U test was used in the non-normally distributed variables'2 independent groups comparison. While normal continuous data were stated as mean±standard deviation; nonnormal continuous data were stated as median (minimum-maximum). Chi squared and Fischer Exact Analysis were used in the test of association among categorical variables. *P*<0.05 was accepted as significant statistically.

Results

During the study, 136 patients had required intubation and mechanical ventilation support in our clinic. Two patients who were operated for esophageal atresia did not receive NIV support post-extubation. Five patients had either severe central nervous system anomalies or hypertonicity, two patients had cardiac disease and chromosomal abnormality resulting congestive heart failure, and 22 patients had missing data on their files were not evaluated. The data of 105 patients [SBP group (n=42) and RAM cannula group (n=63)] were evaluated in the study. The median birth weight of SBP group patients was 1522 gram (530-4620) and the median gestational age was 30.5 week (25-39). The median birth weight of the RAM cannula group was 1760 gram (500-4900) and the median gestational age was 32.0 week (24-41). Both groups were similar regarding the distribution of demographic characteristics and intubation indications (Table 1. and Table 2.). There was no statistically significant difference in the rate of extubation failure between the groups (RAM cannula %44.4 vs SBP %38.1, *p*=0.518) (Table 1.). When comparing the ventilator parameters of the both of the groups; the PEEP value in the RAM cannula group was statistically significantly higher than in the SBPs group (7.0 vs 6.5 cm H20, *P*= 0.038; respectively). It was found that median respiration rates of the patients in Ram cannula group on NIV support is lower than the patients inSBP group (60 vs 62 /minute, *p*=0.032; respectively) (Table3).

Table 1. Demografic and clinical features of patients

	Short Binasal Prong Group (n=42)	RAM Cannula Group (n=63)	p value
Male (n (%))	21 (50)	30 (47.6)	0.811
Birth weight (gram)	1522 (530-4620)	1760 (500-4900)	0.355
Gestational age (week)	30.5 (25-39)	32.0 (24-41)	0.471
Cesarean of delivery (n (%))	40 (95.2)	51 (80.9)	**0.035**
Duration of invasive mechanical ventilation (hour)	52 (12-432)	39 (12-744)	0.778
Extubation time (day)	3 (0-19)	3 (0-62)	0.861
Extubation failure (n (%))	16 (38.1)	28 (44.4)	0.518

Table 2. Distribution of intubation indications of all patients based on groups

	Short Binazal Prong Group (n=42)	RAM Cannula Group (n=63)	p value
Respiratory distress syndrome (n (%))	25 (59.5)	26 (41.3)	
Pneumonia (n (%))	2 (4.8)	7 (11.1)	
Transient tachypnea of the newborn (n (%))	9 (21.4)	10 (15.9)	0.092
Others (n (%))	6 (14.3)	20 (31.7)	

Table 3. Blood gass measurements and the ventilatör values of pre and post extubation

	Pre-Extubation			Post-Extubation		
	SBP (n=42)	**RAM (n=63)**	**P value†**	**SBP (n=42)**	**RAM (n=63)**	**P value†**
MAP (cmH_2O)	7 (5-10)	7 (4-10)	0.156	9 (5.5-12)	9 (7-13)	0.354
PIP (cmH_2O)	16 (11-23)	16 (11-26)	0.200	18 (12-25)	19 (14-30)	0.243
PEEP (cmH_2O)	5 (4-7)	5 (4-7)	0.357	6.5 (4-8)	7 (5-8.5)	0.038
Rate (minute)	33.5 (20-45)	31 (14-46)	0.060	30 (20-36)	30 (20-45)	0.347
FİO2 (%)	30 (21-60)	27 (21-60)	0.055	35 (21-60)	30 (21-100)	0.054
PH	7.32±0.08	7.37±0.08	0.003	7.31±0.07	7.35±0.08	0.008
PCO2 (mmHg)	44.8±8.9	38.1±10.1	0.001	46.6±12.3	40.4±10.8	0.597
HCO3 (mmol/L)	21 (13-35)	22 (14-40)	0.546	21 (16-33)	21 (13-32.90)	0.708
BE (mmol/L)	-1.79±5.56	-2.63±4.71	0.649	-3.04±3.84	-2.59±4.90	0.629
Respiratory rate (minute)				62 (50-72)	60 (34-80)	0.032

SBP: Short binazal prong, RAM: RAM cannula group, MAP: Mean airway pressure, PIP: Peak inspiratory pressure, PEEP: positive end-expiratory pressure, FİO2: fraction of inspired oxygen PCO2: partial pressure of carbon dioxide, HCO3: bicarbonate, BE: Base excess

Discussion

In our study which we had evaluated the effectiveness of two different NIV interfaces in neonatal post-extubation; a statistically significant difference was not found on extubation failure rate between the RAM cannula and SBP groups (%44.4 & %38.1, *p*=0.518; respectively). Also, median PEEP value of the patients inRAM Cannula group was found higher.

Post-extubation NIV support increases to extubation success in neonatal period. In the literature, there are studies compare NIV suppport with RAM cannula as a beginning ventilatory support in the prematüre babies with respiratory distress syndrome. At the same time, a few studies are researching only small groups on the effect of RAM cannula usage as nasal interface in the post-extubation (12-14). Claassen et al. reported that the rate of extubation failure in VLBW newborns who received with NIV support by RAM cannula via Bubble CPAP device was 35% (13). Similarly, in the study of Nezugwu et al., extubation failure rate was found to be 37% in newborns who received NIV support with a RAM cannula (14). In our study, the rate of extubation failure in the RAM cannula group was found as 44%, similar to previous studies.

The effective transmission of the applied pressure to the lungs is closely related to the clinical effectiveness of NIV. Transmission of the pressure to lungs is dependent on type of nasal interface, loss of pressure from mouth and the resistance of airways and ventilator circuit (11). Ramathan et al. reported that all babies tolerated the Ram cannula well and the reintubation rate was 8% in their study, which included 70 patients who were given nasal IMV support with a Ram cannula (15). In Ramathan's study inwhich the group of patients is very heterogeneous between 1st-81st days of postnatal, it has been usedmore high PIP value and comparatively longer inspirium time like 0.5 seconds. In this way, the losses in flow and pressure transmitted to the lungs with a ram cannula have been reduced and lower reintubation rates may have been obtained by providing the transmission of higher pressures to the lungs.

RAM cannula provides easiness and comfort for patients and healthcare providers with its long, thin and can be connected directly to the ventilator's respiration circuit (13-15). Our study found that the median respiratory rate of patients in the RAM cannula group statistically lower than the SBP group. We think that this is related to increased patient comfort and decreased agitation resulting from the design of the cannula.

The longer and thinner tube through which the air flows, the resistance is greater. The RAM cannula leads to more resistance to air flow with its design. In the studies done by artificial lung models, when it is compared with short binasal prongs at the same pressure settings, it is found that the pressure reaching to lungs is lower with RAM cannula (16, 17). When the same pressure is applied with different nasal interfaces, the average air flow pressure which goes to lunges may change significantly. The relation between resistance and flow affects pressure directly (17-19). In the study conduct with three different nasal interfaces by Sharma et al. it was determined that the adjusted CPAP pressure transmitted oropharynx less in the RAM cannula group and it is predicted that high adjusted pressures and velocity of flow increase the success (20). In a six year retrospective study by Claassen et al.; they found that in the CPAP pressure of patients who received NIV support with a RAM cannula increased from year to year in clinical practice and in correlation with this increasing pressure, the failure of CPAP and the rate of intubation in the delivery room is decreased (21).

Considering our previous study and the results of the studies performed on artificial lung models with RAM cannula, we adjust PEEP value 1- 2 cmH20 higher in the patients who NIV support by RAM cannula in our unit. Therefore, the initial PEEP value applied in the RAM cannula group is found higher in our study. We believe that the higher pressure values which are used increases the success of extubation by overcoming the high resistance arisen from the design of the RAM cannula and increasing the pressure reaching to the lungs.

One of the limitations of our study is that it is a single-center and retrospective study. In addition, although there was no statistically significant difference between the groups in terms of clinical characteristics, the fact that the mean gestational age and birth weight of the patients in the RAM cannula group were higher is another limitation of our study.

Conclusion

The type of nasal interface used is a significant step in the successful extubation strategy. RAM cannula is increasingly becoming more used in clinics, because it is comfortable for patients and causes less nasal injury, also is more practical and to esasily bindable by users. Due to the design of the RAM cannula, we argue that applying higher pressures acording to SBP will increase success rate of RAM cannula in clinical practice. However, there are not enough studies which compare the effectiveness of RAM cannula with short binasal prongs in extubation success. As a result, there is a need for randomized controlled trials which evaluating the effectiveness of RAM cannula against commonly used NIV interfaces in more homogeneous groups.

Ethical Approval: *İnönü University Non-Interventional Clinical Research Ethics Committee granted approval for this study (number: 2021/ 1618).*

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Concept: M.F.D, I.K.G.
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