

# The effect of open and closed endotracheal tube suctioning system on respiratory parameters of infants undergoing mechanical ventilation

Parvin Taheri<sup>1</sup>, Narges Asgari<sup>2</sup>, Majid Mohammadizadeh<sup>3</sup>, Mehri Golchin<sup>4</sup>

## ABSTRACT

**Aims:** Mechanical ventilation is used for some infants in neonatal intensive care units (NICU) due to many physiological and clinical causes. Since these patients have endotracheal tubes, cleaning and keeping the airways open through suctioning should be done to increase oxygenation. This study aimed to evaluate effect of open and closed suctioning methods on respiratory parameters of infants undergoing mechanical ventilation.

**Materials and Methods:** In this crossover clinical trial, 44 infants were selected among those undergone mechanical ventilation in NICU of Isfahan's Al-Zahra Hospital using convenience sampling method. The subjects were randomly divided into two groups. In the first group, open suctioning was carried out and after three hours of cleaning, closed suctioning was done. In the second group, closed suctioning was firstly done and following three hours of cleaning, open suctioning was implemented. Respiratory rate (RR) and percentage of arterial blood oxygen saturation was measured before, during and after each type of suctioning. Data were analyzed using repeated measures ANOVA and independent student's t-test.

**Findings:** There was a significant difference between mean respiratory rate and arterial blood oxygen saturation in infants before, during and after the closed and open suctioning. The percentage of arterial blood oxygen saturation had a significant reduction in open method compared to closed method during suctioning and immediately after it. RR three minutes after suctioning showed a significant reduction in both steps in open method compared to closed method.

**Conclusions:** Close method caused fewer changes in hemodynamic status of infants. Therefore, in order to prevent respiratory complications in infants, nurses are recommended to perform the endotracheal tube suctioning by closed method.

**Key words:** Respiratory rate, ventilation, neonate, suction

<sup>1</sup> MSc, Instructor, Department of Pediatric Nursing, School of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran.

<sup>2</sup> MSc Student, Student Research Committee, School of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran.

<sup>3</sup> MD, Associate Professor of Neonatology, Department of Pediatrics, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.

<sup>4</sup> MSc, Instructor, Department of Pediatric Nursing, School of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran.

**Address for correspondence:** Mehri Golchin, MSc, Instructor, Department of Pediatric Nursing, School of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran. E-mail: golchin@nm.mui.ac.ir

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## INTRODUCTION

Implementation of mechanical ventilation in infants with respiratory failure is of special importance. One of the standard care aspects in neonatal intensive care units (NICU) is caring the infants undergoing mechanical ventilator,<sup>[1]</sup> which is done to reduce their need for oxygen.<sup>[2]</sup> Endotracheal intubation is required to establish mechanical ventilation.<sup>[3]</sup> The existence of endotracheal tube causes tissues irritation and increased secretion. It is essential to regularly clean and suction the artificial airway to maintain ventilation.<sup>[4,5]</sup> Although endotracheal tube suction is a device to remove secretions and keep the airways open, it causes many complications. Some of the early complications of suctioning include changes in blood pressure, heart rate, breathing and oxygen saturation percentage.<sup>[6]</sup> Therefore, assessing vital signs during endotracheal tube suctioning is necessary for controlling and preventing more serious complications.<sup>[7]</sup> Late complications have many side effects and risks for infants such as bronchopulmonary dysplasia, intraventricular hemorrhage, patent ductus arteriosus, nosocomial pneumonia and increased duration of

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hospitalization and it can be fatal.<sup>[6]</sup> There are two methods for endotracheal tube suction, open and closed methods. The standard open method for removing secretions of infant's airway is performed by separating the infant from ventilator and crossing the sterilized suction catheter through the endotracheal tube. Closed suction technique is done by connecting an instrument to the ventilator which allows suction catheter enters into endotracheal tube through a one-way valve without removing the infant from the ventilator. Continuation of mechanical ventilation during suctioning would keep positive end-expiratory pressure (PEEP) with minimal changes in fraction of inspired oxygen (FIO).<sup>[8]</sup> One of the advantages of closed suction system is to reduce respiratory pollution and pulmonary infections. Another potential advantage is its easy application which only needs one nurse.<sup>[4]</sup> In closed suction method, nurse would not be infected by patient's endotracheal tube secretions and suction catheter can be used frequently.<sup>[4, 8, 9]</sup> Following principles and choosing a suitable method of endotracheal tube suctioning is also helpful to minimize the complications of endotracheal tube suction.<sup>[7]</sup>

Some studies have shown that infants who have been suctioned by closed method had more physiological stability than those with open method<sup>[8, 10, 11]</sup> and oxygen saturation loss rate reduced with closed method.<sup>[12, 13]</sup> Furthermore, lung volume reduction which is due to the separation of infant from ventilator was reported in the open suctioning.<sup>[14]</sup> Some researchers have suggested that closed suction is the best method for reducing nosocomial infections in neonatal intensive care unit.<sup>[3, 12, 13]</sup>

Considering that very few and limited studies have been done on complications and advantages of these two suction methods for infants and lack of evidence comparing these two methods in Iran, this study aimed to determine the effect of open and closed suction methods on respiratory parameters of infants undergoing mechanical ventilation in Isfahan.

## MATERIALS AND METHODS

This was a crossover clinical trial study which was performed on infants undergoing mechanical ventilation admitted in NICU of Al-Zahra Hospital, Isfahan in 2010. It was ethically approved by the Research Ethics Committee of Isfahan University of Medical Sciences. After receiving written informed consent from the parents, 44 consecutive infants were selected when following inclusion criteria were met: lack of neurological-muscle diseases, congenital heart diseases and its resulted impairment; and lack of active bleeding, fever, endotracheal

intubation and mechanical ventilation for at least 4 hours before the study. Three subjects were excluded from the study due to discontinuation of mechanical ventilation and extubation before completing the data collection. Infants were randomly divided into two groups. In the first step in group A, open suctioning was done and after 3 hours of cleaning, closed suctioning was done as the second step. In the group B, first, closed suctioning was performed and after three hours of cleaning, open suctioning was implemented. Demographic characteristics of the infants entered in the data record form and respiratory rate (RR) as well as percentage of arterial blood oxygen saturation were assessed 1, 2 and 3 minutes before suction, during it, immediately after it and 1, 2 and 3 minutes after the suction. Infants' pulse rate during suctioning was measured through pulse oximetry and intensive care monitor. Arterial blood oxygen saturation was assessed by pulse oximetry. Arterial blood pressure and respiratory rate were recorded by intensive care monitor. Infant's RR was measured by observing on the ventilator. Suctioning was done by a trained nurse.

In open suctioning, after wearing sterile gloves, the rate of catheter insertion was measured, and then the infant was disconnected from the ventilator and 0.2 cc of 0.9% saline was entered into endotracheal tube. Afterward, the suction catheter was slowly and with no pressure inserted into the designated location inside endotracheal tube (0.5 cm more than endotracheal tube size) and thereafter, it was done with pressure of 80 mmHg for 5-10 seconds and the infant was again connected to the ventilator.

The steps of the closed suction included connecting the closed suction catheter to ventilator tube, injection of 0.1 to 0.2 cc 0.9% saline inside catheter and inserting the closed suction catheter inside endotracheal tube from the plastic cover to the pre-measured size (0.5 cm more than endotracheal tube size). Suctioning was applied with pressure of 80 mmHg for 5-10 seconds.

After sampling and assessing the mean of the parameters, due to the lack of difference between 1, 2 and 3 minutes before suction and also after it, as the measured values 3 minutes before and 3 minutes after suction were analyzed using repeated measures ANOVA and independent student's t-test. SPSS software version 16 was used.

## FINDINGS

The two groups were similar in terms of age, sex, birth weight, current weight, gestational age, body temperature, birth rank, ventilator mode and diagnosis of the disease ( $p > 0.05$ ). No significant difference was shown in RR

**Table 1: Mean respiratory rate of infants in different times in closed and open suction methods**

Time	suction	3 min before suctioning		During suctioning		Immediately after suctioning		3 min after suctioning	
		closed	open	closed	open	closed	Open	closed	open
		Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
Sp O <sub>2</sub> (oxygen saturation)	Step1	92.8(4.8)	94.4(6.4)	88.4(6)	89(11.9)	88.7(7.9)	87(10.8)	90.4(7.8)	91(8.6)
	Step2	93.5(2.9)	91.7(8.6)	91(4.8)	80.7(12.9)	90.5(4.2)	81.5(13)	93.3(4)	87.6(12)
Respiratory Rate	Step1	55.5(5.7)	58(5.3)	59.8(5.3)	61.5(3)	57.8(6.3)	61.6(3.3)	59.5(5.5)	58.9(4)
	Step2	57.7(4.3)	59.7(6.6)	61(3.1)	63.3(7.5)	60.2(3.2)	65(4.5)	60.2(2.6)	61.3(4.5)

and oxygen saturation percentage before suctioning between two groups in both steps ( $p > 0.05$ ).

Repeated measures ANOVA showed that mean RR of infants had a significant difference before, during and after the open as well as closed suctioning ( $F = 13.7$ ,  $p < 0.05$ ). Arterial blood oxygen saturation had a significant difference before, during and after open and also closed suctioning ( $F = 10.49$ ,  $p < 0.05$ ).

Moreover, percentage of arterial blood oxygen saturation in open suctioning had a significant reduction compared to closed method during and immediately after suctioning as well as RR three minutes after open suctioning in both steps ( $p < 0.05$ ) (Table 1).

## DISCUSSION

The study of Hoellering et al. showed some changes in heart rate and arterial blood oxygen saturation in open and closed suctioning and a minor reduction in arterial blood oxygen saturation in closed suction was seen in synchronized intermittent mandatory ventilation (SIMV) group.<sup>[15]</sup> In addition, infants showed a better physiological stability in closed suctioning<sup>[8, 10]</sup> and oxygen saturation increased after closed suction; however, this increase was not clinically significant.<sup>[16]</sup> Another study showed that mean of arterial blood oxygen saturation in open suction had a significant difference in different times. Mean of arterial blood oxygen saturation reduced after suctioning the secretions and reached the base rate at 10 and 20 minutes after it.<sup>[17]</sup> There was a significant difference between mean respiratory rate and arterial blood oxygen saturation percentage during and after the open and closed suction. Blood oxygen saturation percentage had a minor reduction during the closed suction and increased after the closed suction which was in line with the present study. A study showed that the difference between mean changes of oxygen saturation in both groups was clearly significant and oxygen saturation drop was significantly lower in closed suction than open one.<sup>[18]</sup> In addition, another study concluded that there was a significant difference in

oxygen saturation which indicated better results of closed suction in comparison with open method.<sup>[8]</sup> The results of present study also showed that arterial blood oxygen saturation percentage in open suction method had a significant reduction during and immediately after the suctioning which was in accordance with the results of other studies.

Results of other studies showed that RR of patients 2 and 5 minutes after suctioning had no significant difference between open and closed methods.<sup>[11,19]</sup> However, another study showed that RR in open suction had a significant increase.<sup>[6]</sup> In contrast, RR had a significant reduction 3 minutes after the suction in this study.

According to the significant reduction of arterial blood oxygen saturation percentage in open suctioning compared to close one during and immediately after suctioning as well as significant reduction of RR three minutes after the open suctioning in the present study, it is recommended that close suctioning be used for infants' endotracheal tube suction.

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