Research Article

Analysis of Factors Related to Extubation Failure in Patients Submitted to Invasive Mechanical Ventilation

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Abstract

Objective: To define the profile of patients submitted to Invasive Mechanical Ventilation (IMV), admitted to a Neonatal Intensive Care Unit (NICU), to identify factors related to failure or failure in the extubation process.

Methods: A retrospective and analytical study, carried out between January 2017 and December 2018, at Maternidade Instituto Cândida Vargas (ICV), Brazil. 448 medical records of patients undergoing IMV were identified. The variables related to the ventilatory modality in question were used, grouped in a database and analyzed by the Chi-square and Mann Whitney tests with a 99% significance level to identify the main factors related to the failure of extubation.

Results: In a total of 448 identified patients, 9.3% of extubation failure was found. Weight, oxygen use time and IMV time are strongly related to extubation failure. The use of the weaning protocol has a negative correlation in removing mechanical ventilation. The use of SBT did not show any influence on the success or not of extubation. The average length of hospital stay for patients with extubation failure was more than twice as high as those who had no failure.

Conclusion: The study concludes that weight, duration of oxygen therapy and exposure to IMV are related to extubation failure. It was found that neonatal care with interventions to prevent extubation failure can reduce the damage caused by the use of prolonged IMV. The best strategy for harm reduction is related to less invasive care, with the use of good practices in ventilatory support.

ABBREVIATIONS

IMV: Invasive Mechanical Ventilation; NICU: Neonatal Intensive Care Unit; MPV: Mechanical Pulmonary Ventilation; SBT: Spontaneous Breath Test; FiO2: Oxygen Fraction; PEEP: Positive Expiratory Pressure; RR: Respiratory Rate.

INTRODUCTION

Invasive mechanical ventilation (IMV) is a method of ventilatory support in which a prosthesis is introduced into the airways of patients with respiratory failure to guarantee gas exchange [1]. This procedure is of fundamental importance in Neonatal Intensive Care Units (NICU), since about 70% of preterm newborns and 30% of pediatric patients require mechanical ventilation [2,3]. Some characteristics of the respiratory system of pediatric patients, especially PTNs, such as narrower airways, fewer alveoli, deficient collateral ventilation and decreased or absent surfactant, justify these high numbers of patients who lack IMV [4].

Although mechanical pulmonary ventilation (MPV) is essential for maintaining the life of these patients, the use of this resource for a long time can lead to complications, such as bronchodysplasia, periventricular hemorrhage and the development of lesions in other organs, including the brain [5,6]. The transition from artificial to spontaneous ventilation in patients who remain on mechanical ventilation for more than 24 hours is called weaning [7]. Suppose there is a failure in this process. In that case, the patient will need to be reintubated, with reintubations occurring in about 20% of patients undergoing interruption of IMV, which increases the length of hospital stay and the risk of infections, trauma and morbidity and mortality [8]. Therefore, the correct time for extubation must be determined, reducing the risk of these complications.

The ideal time for the removal of MPV is often based on clinical and laboratory parameters, available at the time of extubation decision. However, these parameters are not very objective, which makes the withdrawal of this support in the NICUs, an action of trial and error [5]. Thus, when extubation failure can be predicted accurately, extubation can be better programmed and the trauma of reintubation avoided [2].

Therefore, the present study aims to outline the profile of patients admitted to a reference Neonatal Intensive Care Unit from January 2017 to December 2018 who underwent IMV, to determine the factors related to failure extubation, to understand how to minimize its frequency.

MATERIALS AND METHODS

A retrospective, quantitative and descriptive study, in which the medical records of patients undergoing IMV were analyzed within the Neonatal Intensive Care Unit (NICU) of the Maternity Institute Cândida Vargas (ICV), state of Paraíba, Brazil, reference service in high-risk pregnancies. Between January 2017 and December 2018, 525 patients were admitted; however, among these, 77 were excluded for presenting the following conditions: patients with congenital malformations incompatible with life and patients who were removed from ventilatory support before completing 24 hours. Therefore, the study sample totaled 448 individuals, composed of neonates of both sexes, admitted to the NICU, submitted to IMV for more than 24 hours.

The information contained in the medical records was recorded in an electronic spreadsheet, with the following variables: the weight of the patient at birth; weight variation from the beginning of the use of IMV until extubation; length of stay in the NICU; start date of VMI and extubation; total oxygen use time; patient outcome; use of extubation protocol; use of the Spontaneous Breath Test (SBT); accidental extubation.

Planned extubation was considered to be those in which the procedure met the weaning criteria established and used by the reference service, namely hemodynamic and respiratory stability, use of oxygen fraction (FiO2) less than 40%, Positive Expiratory Pressure (PEEP) less than 5 mmHg, respiratory rate (RR) total less than 50 and withdrawal of sedation, without using vasoactive drugs or at least only using dopamine with doses less than 5 mcg/kg/min.

Patients who were extubated without prior planning had the process considered as empirical extubation, which was based only on the clinical experience of the medical professional. The procedure was also classified as failed extubation, in cases where, after a period of fewer than 48 hours, the patient needed to be reintubated. The inadvertent withdrawal of the IMV characterizes accidental extubation.

The collected data were analyzed using software R, in the public domain, version 4.0.0, where the Mann-Whitney's Chi-Square and U tests were applied.

This study received approval from the Research Ethics Committee of the Health Sciences Center of the Federal University of Paraíba (Approval number: 26381919.0.0000.5188).

RESULTS AND DISCUSSION

In this study, it was demonstrated that 448 newborns underwent IMV, of which 42 (9.3%), had extubation failure. The analyzed database, which contains the profile of the patients included in the study, contains clinical data from the sample, in addition to including work processes implemented in the listed reference service.

It can be noted, by reading Table 1, that of the 164 patients who underwent the weaning protocol, 82.1% did not fail, whereas in the other neonates, whose extubations were not performed using the protocol, the procedure was successful in 95.5% of cases, with the interruption of ventilatory support being performed empirically, based on clinical experience. Therefore, the application of the weaning protocol, in the reference unit studied, showed a negative correlation.

Among the 146 neonates who underwent the SBT strategy, it is understood, from Table 2, that 15.8% had extubation failures, while the others, in which SBT was not applied, the percentage of failures was 6.3%. In this perspective, from the analysis of the data obtained, it was found that the SBT does not fit as an effective variable, for this sample, in the success in extubation.

It is possible to notice that, in Table 3, neonates weighing less than 1500 grams occupy the group most prone to failure in weaning, accounting for 20 failures, which corresponds to a 47.6% prevalence. It is also noticed that 78.1% of the patients without failure did not suffer accidental extubation; 45.5% of cases with failed weaning coincide with patients who have suffered unintentional extubation. Given the analysis of the 448 records, it is clear that there were a total of 108 accidental extubations, that is, the proportion was approximately 4 occurrences for every 100 intubated patients, which highlights factors related to failures in assistance and monitoring of parameters ventilation.

As for the time of use of IMV, it was found, in Table 3, that the average exposure time for patients who failed and who did not fail was, respectively, 31.02 and 11.38 days.

As for the use of O^2, it was noticed that the average number of days was 14.87 for patients who did not fail and 38.05 for neonates who had extubation problems, highlighting that failure in extubation makes these newborns more vulnerable to the consequences of oxygen therapy.

Concerning evolution, according to Table 3, 21.4% of the neonates who failed died and, on average, the length of hospital stay (from admission to the NICU to the outcome of discharge/ transfer/death) was 36.41 days (SD = 34.58). For patients who did not experience extubation failure, the average hospital stay was

Table 1: Use of weaning protocol.

Weaning patients	With protocol (n=164)		Without protocol (n=286)		Sig.
No extubation failure	133	82,1%	273	95,5%	<0,0001*
With extubation failure	29	17,9%	13	4,5%	
* Chi Square Test					

Table 2: Use of SBT strategy.

Weaning patients	With SBT (n=146)	Without SBT (n=302)	Sig.
No extubation failure	123 84,2%	283 93,7%	0,0056*
With extubation failure	23 15,8%	19 6,3%	
* Chi Square test			

Table 3: Clinical Profile of Neonates submitted to IMV.			
Clinical Profile	**No extubation failure (n=406)**	**With estubation failure (n=42)**	**Sig.**
Weight (g)			
<1500	191 (47,0%)	20 (47,6%)	
1500 |-- 2000	72 (17,7%)	5 (11,9%)	<0,001**
2000 |-- 2500	40 (9,9%)	4 (9,5%)	
2500 |-- 3000	21 (5,2%)	7 (16,7%)	
> 3000	73 (18,0%)	6 (14,3%)	
Unknown	9 (2,2%)	0 (0,0%)	
Accidental Extubation			
No	317 (78,1%)	23 (54,8%)	
Yes	89 (21,9%)	19 (45,2%)	0,0038*
VMI usage time (days) Mean (SD)	11,38 (20,29)	31,02 (35,25)	<0,0001**
Total O² usage time (days) Mean (SD)	14,87 (21,46)	38,05 (35,42)	<0,0001**
Weight variation to extubation			
Reduction greater than 250g	21 (5,2%)	1 (2,4%)	0,0017*
Reduction between 1 and 250g	113 (27,8%)	12 (28,5%)	
Increase up to 250g	185 (45,6%)	9 (21,5%)	
Increase greater than 250g	87 (21,4%)	20 (47,6%)	
Outcome			
Hospital discharge/ Transference	249 (61,3%)	33 (78,6%)	
Death	157 (38,7%)	9 (21,4%)	0,0710*
Length of stay (days) Mean (SD)	15,77 (28,05)	36,41 (34,58)	<0,0001**
* Chi Square test ** U of Mann-Whitney test			

15.77 days (SD = 28.05). As for weight variation until extubation, 47.6% of neonates who failed increased by more than 250 grams. The weight variation of these neonates, when compared to those who did not experience extubation failure, differed significantly, since most patients (45.8%), had an increase in weight of up to 250 grams.

Removing a patient from mechanical ventilation is sometimes a more complicated process than its permanence [9]. As a result, it is necessary to try to establish accurate and reproducible predictors of weaning [10]. Therefore, the present study shows factors related to neonatal extubation failures, based on clinical data from the analyzed sample, and work processes implemented in the assistance service.

Among the risk factors evidenced by the study, the patient's weight stands out. The analysis of the study sample attests to the group of neonates that weigh less than 1500 grams as being the most prone to extubation failure. Such evidence is corroborated by the existing literature, which describes a direct relationship between lower weight and a higher propensity for extubation

failures [11]. According to Costa, Lobato and Guimarães [12], "weight is a more reliable predictor of success or failure of extubation than other tests and indexes", and it is also related to the maturity of the newborn's respiratory muscles, which is essential for spontaneous breathing.

The existing literature confirms the usefulness of the SBT to select patients ready for extubation[7] to avoid failures. Andrade et al. [13], for example, submitted 30 neonates to the SBT and found that 66.7% of them were successful in extubation. Thus, the use of SBT for the daily assessment of weaning parameters is described in the literature as one of the factors responsible for the good evolution observed in patients on IMV [14]. Several studies show that SBT decreases the chances of extubation failure and significantly increases the chances of success in both adults and neonates, although it is not an infallible test [14,15]. However, the results found in this study pointed out that the performance of the SBT did not have a positive impact on the success rate of extubation, since 15.8% of the neonates who underwent the SBT failed during weaning, whereas only 6.3% those who were not submitted to the SBT failed.

The results obtained are in line with the systematic review and meta-analysis developed by Shalish et al. [16], in which it is stated that although the SBT is an attractive assessment tool, it is still necessary to develop studies of higher methodological quality, with the use of larger samples to elucidate the efficiency of the use of SBT in the prognosis of success or failure of extubation in more vulnerable babies.

It is known that with the newborn's submission to IMV, O2 is administered for as long as necessary for each condition. In the sample evaluated, patients with extubation failure had an O2 exposure time 60.02% longer than patients who had successful extubation. According to Friedrich, Corso and Jones [17], "exposure to high concentrations of oxygen can induce a reduction in the formation and development of the alveoli, causing a series of histopathological changes". This toxic effect resulting from long periods of oxygen therapy is even more pronounced in neonates, as they do not have fully developed antioxidant systems, making the patient more susceptible to pathologies caused by free radicals of O_2 [18], which can lead to Pulmonary Bronchodysplasia, Neobronchodysplasia [19], Retinopathy of Prematurity [20], weight reduction and head circumference [17].

Aspects related to the result of the application of the weaning protocol differed from what was expected. According to Colombo [21], the establishment of the weaning protocol would increase the success rates and decrease the number of failures in extubation. Besides, the failure to use a protocol contributes to the extubation process becoming even more imprecise, which can cause early extubation or unnecessary prolongation of exposure to IMV [22].

However, the results obtained through this study showed that among the 286 patients who did not undergo the weaning protocol, 273 (95.5%) did not experience extubation failure, in these cases the clinical experience of the health professional was essential for the success in extubation. Among the neonates who underwent the protocol, 82.1% had no failures, in order to demonstrate that the use of the protocol had a negative influence

on the non-occurrence of failures. In pre-existing studies by Bhat [23], and Gillespie [24], no significant differences in failure rates were found between the group submitted to weaning strategies and the group subject only to empirical extubation.

Although the reasons for these divergences have not been elucidated through this study, it is understood that they may result from the inadequate application of the protocol by the NICU health team, or even a mistake in the protocol structure adopted by the unit, therefore, it is necessary to conduct further research in order to analyze the reason for these disagreements.

Accidental extubation is an eventuality due to several reasons, such as patient mobilization itself, nature of secretions and type of ventilatory support used [25]. In the literature, the incidence is between 0.92 and 3.3 for 100 patients on IMV per day [26,27], lower than the average of 4 for every 100 neonates ventilated per day in this study. The individual's reintubation often follows this phenomenon, increasing the chances of injuries to the upper airways [26], nosocomial infections, increased hospital stay [28,29], and bronchopulmonary dysplasia, which implies an increase in oxygen therapy time and a consequent increase in the difficulty in performing, successfully extubation.

It was also noticed that the length of stay (in days) of patients who failed was more than double those who did not, presenting an average of 36.41 days. This may be due, above all, to the fact that the reintubation process is closely related to morbidity and mortality, as mentioned above [30]. Also, according to Danan et al. [31], the shorter hospital stay and extubation failure can establish a cause and consequence relationship, suggesting that the inability to wean may be caused, for example, by the lack of maturation the function of the respiratory system and the low alveolar stabilization, leading to extubation failure and prolonged exposure time to IMV.

CONCLUSION

After analyzing the medical records, regarding weight, a higher prevalence of failure was found in premature neonates weighing less than 1500g. Among the patients, it was observed that the length of stay in the NICU of newborns who had failed extubation was longer than those who were successful. No evidence was found to support SBT as an effective predictor of extubation failure in these patients. As for the use of the protocol, the inefficiency in its application in the researched maternity was proven, which may suggest inadequate adherence to the use of the protocol or adoption of inappropriate parameters. Therefore, the reduction of failures, damages and length of hospital stay is directly related to the implementation of efficient care practices for newborns in IMV and the clinical experience of the health professional to indicate the best time for weaning.

In this sense, it was noticed that the observation of such factors by the service team is an important step that may suggest the success or not of an attempted extubation. Finally, it is noteworthy that this study was limited by the small sample, as well as the limited and predetermined number of variables used in the institution's service protocol.

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