

Extubation failure in pediatric intensive care unit: a retrospective cohort study

Falha de extubação em unidade de terapia intensiva pediátrica: estudo de coorte retrospectivo

Fracaso de la extubación en una unidad de cuidados intensivos pediátrica: un estudio de cohorte retrospectivo

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ABSTRACT | In the pediatric intensive care unit (ICU), extubation failure may increase mortality risk. This study aimed: (1) to verify the rate of extubation failure in the pediatric ICU of a public hospital located in the city of Bauru (São Paulo, Brazil); (2) to identify the main cause attributed to extubation failure; (3) to evaluate whether age and time of invasive mechanical ventilation (IMV) are characteristics associated to extubation failure; (4) to evaluate whether the length of stay in the ICU/hospital is longer among patients who presented extubation failure. A retrospective study was performed with 89 hospitalized patients from May 2017 to July 2018. Results showed an extubation failure rate corresponding to 16%. The main cause attributed to extubation failure was laryngeal stridor, totaling 57% of the cases. Intergroup comparison (success vs. failure of extubation) showed no differences in relation to age ($p=0.294$) and IMV time ($p=0.228$). However, we observed that the extubation failure group had longer ICU ($p=0.000$) and hospital time ($p=0.010$). In this way, we conclude that the rate of extubation failure is in agreement with other studies. Laryngeal stridor was responsible for more than half of cases of extubation failure. Although IMV time and age were not associated with the extubation failure, they contributed to a longer stay in the ICU and in the hospital.

Keywords | Intensive Care Unit; Pediatrics; Mechanical Ventilation; Airway Extubation.

RESUMO | Na unidade de terapia intensiva (UTI) pediátrica, a falha de extubação pode aumentar o risco de mortalidade. Este estudo objetivou: (1) verificar a taxa de falha de extubação na UTI pediátrica de um hospital público do município de Bauru (São Paulo, Brasil); (2) identificar a principal causa atribuída à falha de extubação; (3) avaliar se características como a idade e o tempo de ventilação mecânica invasiva (VMI) estão associadas à falha de extubação; (4) avaliar se o tempo de permanência na UTI e hospital é maior entre os pacientes que apresentaram falha de extubação. Foi realizado estudo de coorte retrospectivo com 89 pacientes internados de maio de 2017 até julho de 2018. Os resultados mostraram taxa de falha de extubação correspondente a 16%. A principal causa atribuída à falha de extubação foi o estridor laríngeo, totalizando 57% dos casos. A comparação intergrupos (sucesso vs. falha de extubação) não mostrou diferenças em relação à idade ($p=0,294$) e ao tempo de VMI ($p=0,228$). No entanto, observamos que o grupo falha de extubação apresentou maior tempo de UTI ($p=0,000$) e hospital ($p=0,010$). Desta forma, concluímos que a taxa de extubação está de acordo com a observada em outros estudos. O estridor laríngeo foi responsável por mais da metade dos casos de falha de extubação. Embora a idade e o tempo de VMI não tenham sido características associadas à

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falha de extubação, esta contribuiu para o maior período de permanência na UTI e no hospital.

Descritores | Unidade de Terapia Intensiva; Pediatria; Ventilação Mecânica; Extubação.

RESUMEN | En la unidad de cuidados intensivos (UCI) pediátrica, el fracaso de la extubación puede aumentar el riesgo de mortalidad. Este estudio tuvo el objetivo de: (1) verificar el índice de fracaso de la extubación en la UCI pediátrica de un hospital público en el municipio de Bauru (São Paulo, Brasil); (2) identificar la causa principal atribuida al fracaso de la extubación; (3) evaluar si las características edad y tiempo de ventilación mecánica invasiva (VMI) están asociadas al fracaso de la extubación; (4) evaluar si la duración en la UCI y el hospital es mayor entre los pacientes que experimentaron este fracaso. Se realizó un estudio de cohorte retrospectivo con 89 pacientes hospitalizados desde mayo de 2017

hasta julio de 2018. Los índices del fracaso de la extubación fueron del 16%. El estridor laríngeo fue la causa principal atribuida al fracaso de la extubación, lo que totaliza el 57% de los casos. La comparación intergrupala (éxito versus fracaso de la extubación) no presentó diferencias en relación con la edad ($p=0,294$) y el tiempo VMI ($p=0,228$). Se observó que el grupo fracaso de la extubación estuvo más tiempo en la UCI ($p=0,000$) y el hospital ($p=0,010$). Se concluye que el índice de extubación está en consonancia con lo observado en otros estudios. El estridor laríngeo fue el responsable de más de la mitad de los casos de fracaso de la extubación. Las características edad y el tiempo de VMI no estuvieron asociadas al fracaso de la extubación, pero esta contribuyó a un período más prolongado en la UCI y en el hospital.

Palabras clave | Unidad de Cuidados Intensivos; Pediatría; Ventilación Mecánica; Extubación.

INTRODUCTION

The process of discontinuing invasive mechanical ventilation (IMV) is divided into two stages: the removal of the ventilatory support, known as weaning, and the removal of the artificial airway, defined as extubation¹. Extubation failure is characterized by the patient's inability to maintain spontaneous breathing, requiring a return to IMV within 48 hours after extubation².

In pediatrics, the extubation failure rate can vary from 2% to 20%, depending on the place of service and characteristics of the population³. Among the main negative consequences for pediatric patients, extubation failure is associated with unfavorable clinical outcomes, such as increased length of stay in the intensive care unit (ICU), longer IMV time and, consequently, the need for tracheostomy⁴. In addition, other studies have associated extubation failure with an increased risk of mortality^{5,6}.

Although the causes are almost always multifactorial, extubation failures have been associated with several risk factors. The age and time of IMV, for example, are considered important risk factors for extubation failure in children^{5,7}. Studies have shown that the younger the child and/or the longer the IMV time, there is an increased risk for extubation failure^{5,7}. Despite this, there are still contradictory studies, in which there was no influence of age⁸ or time of IMV⁹ on extubation failure.

In view of the exposed context, and considering the negative repercussions caused by extubation failure,

which also implies a higher cost for the treatment of the patient¹, it is essential to know the occurrence of such events, their causes and possible risk factors. Thus, based on such characterization, it becomes possible to plan and elaborate coordinated strategies, involving the multidisciplinary team, in an attempt to prevent and/or minimize the risk factors associated with extubation failure.

Thus, the objectives of this study were: (1) to determine the extubation failure rate in the pediatric ICU of a public hospital located in the city of Bauru (São Paulo, Brazil); (2) identify the main cause attributed to extubation failures; (3) assess whether characteristics such as age and IMV time are associated with extubation failure; and (4) assess whether the length of stay in the ICU and hospital is longer among patients who have failed extubation.

METODOLOGY

This study was approved by the Scientific Committee of the State Hospital of Bauru (HEB). This is a retrospective cohort study conducted with patients admitted to the pediatric ICU of HEB (São Paulo, Brazil), from May 2017 to July 2018. The pediatric ICU of HEB consists of 11 beds and has a multidisciplinary team formed by pediatric intensive care doctors, nurses, nursing technicians, physical therapists, psychologists, nutritionists, occupational therapists and speech therapists.

Patients of both sexes aged 28 days to 17 years, and with IMV time greater than 24 hours were included. Only patients with respiratory drive, hemodynamic stability, normal acid-base balance, positive end-expiratory pressure (PEEP) ≤ 8 and inspired oxygen fraction (FiO₂) $\leq 50\%$ were considered fit for extubation. The patients were extubated after successfully completing the spontaneous breathing test, which was carried out from 30 minutes to two hours, with ventilation in pressure support mode, with pressure support of $\leq 10\text{cmH}_2\text{O}$, PEEP of $5\text{cmH}_2\text{O}$ and FiO₂ $\leq 50\%$ ¹⁰. Accidental extubations, patients transferred from service, undergoing tracheostomy or who died before the first extubation were excluded (Figure 1). Medical records with incomplete data, which made it impossible to analyze the results, were also excluded.

For data collection, electronic medical records of hospitalized patients were consulted and reviewed, as

well as specific spreadsheets for extubation control and management. Thus, the following information was collected: age, sex, medical hypothesis at the time of hospitalization, use of corticosteroids before extubation, use of post-extubation non-invasive ventilation (NIV), time from IMV until the first extubation, length of stay in the ICU and in the hospital.

Extubation failure was characterized by the need for new intubation and return to IMV within 48 hours after removal of the orotracheal tube^{2,10}. The decision to reintubate was made when the patient had two or more clinical criteria: increased respiratory rate by more than 40% from normal for age, apnea >20 seconds, subdiaphragmatic or suprasternal circulation, cyanosis and/or decreased level of consciousness with insufficient respiratory effort¹⁰. NIV in the 48 hours after extubation was used in specific cases, respecting the indications and contraindications of the therapy¹¹.

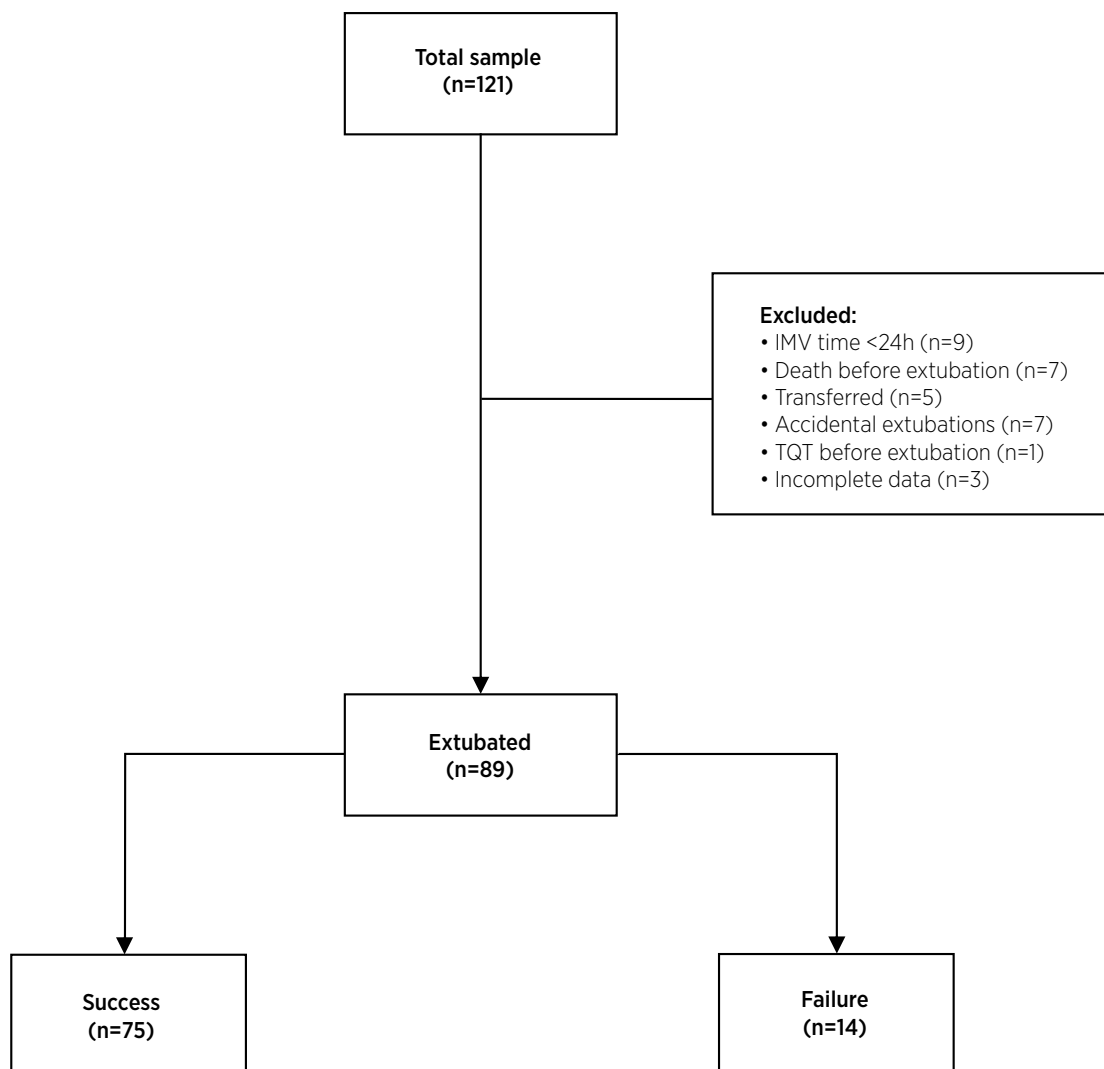


Figure 1. Flowchart of patients in the study
IMV: invasive mechanical ventilation; TQT: tracheostomy.

Statistical analysis

The results were analyzed using the Statistical Package for Social Sciences for Windows (IBM®, USA), version 20.0. Categorical variables were described in absolute and relative frequency. For quantitative variables, the normality of the data was verified by the Shapiro-Wilk test. As the data presented a non-normal distribution, they were described as median (interquartile range 25-75%). The comparison between the groups (success vs. extubation failure) was performed using the Mann-Whitney U test or chi-square test. In all analyzes, the result was considered significant when $p < 0.05$.

RESULTS

The total sample consisted of 121 patients, 32 of whom were excluded according to the previously established criteria (Figure 1). In the sample studied ($n=89$), the extubation failure rate corresponded to 16%. Among the causes attributed to extubation failure, laryngeal stridor was the most frequent, with 57% ($n=8$) of cases. In the intergroup comparison (Table 1), we did not find any significant difference for the variables primary disorder, age, sex, use of corticosteroids, use of NIV and time of IMV. On the other hand, we observed that the extubation failure group had a longer stay in the ICU ($p=0.000$) and in the hospital ($p=0.010$).

Table 1. Characteristics and outcomes of extubation success and failure groups

Variables	Extubation success (n=75)	Extubation failure (n=14)	p
Primary disorder			
Respiratory, n (%)	49 (65)	11 (79)	0.332
Cardiovascular, n (%)	4 (5)	0 (0)	0.377
Neurological, n (%)	6 (8)	1 (7)	0.913
Digestive, n (%)	5 (7)	0 (0)	0.320
Endocrine, n (%)	5 (7)	1 (7)	0.948
Integumentary, n (%)	6 (8)	1 (7)	0.913
Males, n (%)	42 (56)	10 (71)	0.282
Age (months)	19 (4-89)	37 (10-65)	0.294
Age groups			
28 days-2 years old, n (%)	41 (54)	6 (43)	0.416
>2-7 years, n (%)	14 (19)	5 (36)	0.153
>7-17 years, n (%)	20 (27)	3 (21)	0.681
Use of corticosteroids, n (%)	31 (41)	2 (14)	0.054
Use of NIV, n (%)	14 (19)	5 (36)	0.153
VMI time (hours)	119 (61-189)	141 (92-175)	0.228
ICU time (days)	10 (6-13)	17 (14-23)	0.000
Hospital time (days)	16 (11-25)	24 (17-59)	0.010

Results expressed in absolute frequency (%) or median (interquartile range 25-75%). NIV: non-invasive ventilation; IMV: invasive mechanical ventilation; ICU: intensive care unit.

DISCUSSION

Our results showed that the extubation failure rate corresponded to 16%, with laryngeal stridor being the cause most often associated with failure cases. Contrary to our initial hypotheses, age and IMV time were not risk factors for extubation failure. On the other hand, we confirm that extubation failure is associated with longer ICU stay and hospital stay.

In the pediatric population, the rate of extubation failure can vary from 2 to 20%³. Therefore, based on our results, we can say that the extubation failure rate (15.7%) corroborates what was found in other tests. Despite this, the considerable variation in the results in the various studies can be attributed, above all, to the different methodological criteria adopted. For example, Khan, Brown and Venkataraman¹² studied a population of 208 pediatric patients and observed an extubation

failure rate equivalent to 16.3%. However, in the same study, the researchers excluded cases of reintubation due to upper airway obstruction, which may have contributed to underestimating the results.

In another example, Edmunds, Weiss and Harrison⁷ evaluated a population of 632 pediatric patients and found extubation failure in 4.9% of the studied sample. In the same study, the authors considered a time of up to 72 hours for the event. Despite the low rate of extubation failure, this criterion may have contributed to the overestimation of cases of extubation failure, since, obviously, the chance of failure becomes greater in 72 hours when compared to the 48-hour period.

In our study, laryngeal stridor was the cause most frequently associated with extubation failure, corresponding to approximately 57% of cases. This high incidence of stridor after extubation is also observed in other studies with pediatric patients. Edmunds, Weiss and Harrison⁷, Baisch et al.⁹ and Kurachek et al.⁵, for example, observed that stridor was the most common cause for extubation failure, with a frequency of 25%, 35% and 37%, respectively.

Unfortunately, as there is no “gold standard” method for predicting or preventing post-extubation stridor, the outcome turns out to be difficult to control. The cuff leak test, or airway permeability test, with a high degree of diagnostic accuracy in the adult population¹³, does not have the same predictive capacity in the pediatric population¹⁴, especially in children under 7 years old¹⁵. Other less common methods, such as laryngeal ultrasound¹⁶ and inductive inductance plethysmography¹⁷, even though they have shown good results in the identification of laryngeal edema, are still limited in clinical practice, since specific equipment and training are required for its management.

In addition to the difficulty in predicting laryngeal stridor, preventive methods have not yet become a consensus in clinical practice. The prophylactic administration of corticosteroids, for example, although it does not have proven effectiveness, has shown consistent results and with beneficial trends in the prevention of laryngeal stridor in children¹⁸. Interestingly, such positive trends converge with that found in our study, in which we observed that the successful extubation group had a greater number of patients who used corticosteroids in the pre-extubation moment. Although our result was not statistically significant ($p=0.054$), it can be considered clinically relevant, since it corroborates the trend verified in the literature.

With regard to risk factors, we observed that age was not associated with extubation failure. Our findings corroborate that found by Khemani et al.⁸; however, they contradict several other studies^{5,7,9,19} in which it was observed that the children in the extubation failure group were younger when compared to those in the successful group. The hypothesis that would justify such an association is largely attributed to the anatomical and functional development of the child’s respiratory system. The immaturity of the collateral ventilation system, the high compliance (and low elastance) of the rib cage, the increase in airway resistance (mainly up to 5 years of age)²⁰, and the lower prevalence of type I²¹ diaphragmatic fibers are some factors that influence the child’s ability to breathe spontaneously and may contribute to extubation failure.

Regarding the IMV time, we did not verify its influence on extubation failure, since there was no difference between the groups studied. Although our findings corroborate that verified by Baisch et al.⁹, most studies^{5,7,8,19,22} found opposite results, that is, the longest IMV time was associated with cases of extubation failure. Despite this, it cannot be said that there is a cause and effect relationship between IMV time and extubation failure, especially since most studies have other possibly confounding factors.

Thus, and considering that the age and time of IMV were not risk factors in our study, we can assume that extubation failure was influenced by other unmeasured phenomena. Malnutrition³, respiratory muscle weakness⁸, high oxygen concentrations²², electrolyte disturbances²³, use of vasoactive drugs⁵ and prolonged sedation²² are some examples of factors associated with extubation failure, which, due to the lack of control and accurate recording of such information, were not considered in this study.

As for the outcomes observed in our study, we found that extubation failure was associated with longer ICU stay and hospital stay. Such results are in line with those found in other studies^{5,9,19}. Although other factors may influence the length of hospital stay, we understand that extubation failure is directly associated with outcomes, as these patients, in most cases, need to return to sedation, a new ventilatory weaning process, in addition to being more susceptible to complications inherent to IMV, such as atelectasis and pneumonia²⁴, which can prolong treatment time. In addition, as verified by Laham, Breheny and Rush¹⁹, it is likely that the longer hospital stay, as an effect of extubation failure, implied

higher financial costs to the hospital, even though we have not analyzed such an outcome.

Finally, we must highlight some limitations of our work. The first is inherent to the nature of the study, in which the retrospective design prevents the registration and control of other factors that could influence the phenomenon studied. In addition, we consider the scope of the study to be limited, since it was carried out in only one unit, and therefore comparisons with works conducted in other locations should be made with caution.

CONCLUSION

This study contributed to expand the knowledge about extubation failure in the pediatric population. In the studied unit, we verified an extubation failure rate equivalent to 16%, which corresponds to that observed in other reference services. Additionally, as the laryngeal stridor was responsible for more than half of the cases of extubation failure, we consider it essential to continue the search for accessible methods that help in the prediction and prevention of such condition. In our sample, age and time on mechanical ventilation were not risk factors for extubation failure, suggesting the involvement of other unmeasured conditions. Finally, we emphasize the importance of developing strategies that minimize extubation failures, as they prolong the hospital stay and, presumably, increase the costs of treating the patient.

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