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Andes pediatr. 2023;94(5):597-605
DOI: 10.32641/andespediatr.v94i5.4583

ORIGINAL ARTICLE

Overnight extubation is not associated with extubation failure in pediatric intensive care unit patients: a retrospective cohort study

La extubación durante la noche no se asocia con su fracaso en pacientes pediátricos de Unidad de Cuidados Intensivos: Estudio de cohorte retrospectivo

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Received: October 26, 2022; Approved: April 17, 2023

What do we know about the subject matter of this study?

There is a common practice of extubating pediatric patients on mechanical ventilation during the daytime; it is believed to be safer and with fewer complications compared with extubation at night.

What does this study contribute to what is already known?

Patients extubated at night, compared with those extubated during the day, do not have a higher extubation failure rate and have a shorter duration of mechanical ventilation. Extubation should be based on clinical factors rather than time of day.

Abstract

There is little known about the time of the day and the nature of it (business day/non-business day) at which extubation is performed, and whether it is safe during the night. **Objective**: to describe the frequency of nocturnal extubation (NE) and non-business day extubation (nBDE). In addition, to determine the association between these and clinical outcomes. **Patients and Method**: Retrospective cohort study of patients under 18 years of age who received invasive mechanical ventilation (MV) and underwent an extubation attempt in a high complexity Pediatric Critical Patient Unit (PCPU) between 01/01/2018 to 12/31/2021. Primary exposure: NE, which was defined as that performed between 20:01 and 8:00 hours. Its association with extubation failure (EF), duration of invasive MV, and length of stay in the PCPU was evaluated. **Results:** 146 patients were included [58.9% males, age 1.14

Keywords:
Children;
Airway Extubation;
Respiratory Failure;
Mechanical Ventilation;
Pediatric Intensive Care

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Edited by:
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How to cite this article: Andes pediatr. 2023;94(5):597-605. DOI: 10.32641/andespediatr.v94i5.4583

(0.25 - 5.5) years]. NE was performed in 17.8%. Nocturnal extubation was not associated with EF nor was the day of extubation. The EF was 3.8% in NE and 5% in daytime extubation (DE) (p = 0.80). Duration of invasive MV was shorter in NE than DE [48 (24-73.5) vs. 72 (48-96) h, p = 0.02]. **Conclusions:** NE was not associated with EF. Patients with NE had shorter duration of invasive MV, and the latter was associated with EF. Withdrawal of invasive MV should be considered at the first opportunity and be determined by clinical factors, rather than time of day.

Introduction

Routinely and unnecessarily prolonging the duration of invasive mechanical ventilation (MV) when the patient is ready to be extubated is not harmless[1]. On the other hand, the early withdrawal of MV as soon as the appropriate criteria are met, with previously established criteria, has demonstrated benefits[2]. From the above, it can be concluded that the decision to extubate the patient after a spontaneous breathing trial (SRT), an integral part of the set of measures for extubation readiness testing, to minimize exposure to invasive MV[3,4] should be a continuous process, measured in hours rather than days and should require the participation of the entire health care team[5].

It could be because they follow a custom, but the fact is that the current policy of extubation of pediatric patients is carried out in most hospital centers mainly after the morning rounds or during daytime hours[6], probably due to the idea or belief that there are greater complications if this is done at night[7,8].

Recent studies in adults suggest the opposite[2], and similar findings have been reported in large neonatal[9] and pediatric centers in developed countries[10]. However, the operation of many Latin American pediatric Intensive Care Units (ICUs) has some considerations during night shifts or non-working days that may influence this decision. Factors such as the availability and training level of medical staff (intensivist physicians) and nursing teams, lower physician-to-patient and nurse-to-patient ratios, the absence of respiratory therapists, delayed access to diagnostic technology, and support from specialized services can play a role. Furthermore, in addition to the increased workload associated with night shifts, there is documented evidence of possible errors due to healthcare workers' physical and mental exhaustion during night shifts[10-12].

There is limited research on the timing of extubation in the pediatric population, with only one study conducted in Latin America examining the relationship between daytime versus nighttime extubation timing and its impact on extubation outcomes [3,9,10]. The objective of this study was to determine whether the time (day versus night) and type of the day (working or non-working) when extubation is performed were associated with: 1) extubation failure (EF) and 2) the duration of mechanical ventilatory support and stay in the Pediatric Critical Care Unit (PCCU). We hypothesized that EF is not associated with the time or day of the week of extubation.

Patients and Method

This study was approved by the Scientific Ethical Committee of the Southeast Metropolitan Health Service, Ministry of Health of Chile, on August 22, 2022.

Setting

The PICU of the *Hospital Dra. Eloísa Díaz* is located in Santiago, Metropolitan Region, Chile. It has twelve multifunctional hospital beds for patients up to 18 years of age, whose admission criteria are either critical care or intermediate care. The hospital is a highly complex university hospital. The hospital does not perform heart surgery or solid organ or bone marrow transplants in children. Annually, the PICU receives approximately 450 admissions and 13% of all patients require invasive MV, with an average duration of 67 hours (42.5-92.2) in 2019.

From Monday to Friday (working day), each day shift consists of four intensivists in the morning (8:00 am to 2:00 pm), two resident physicians, an intensivist or pediatrician (24-hour shift), three clinical nurses, with a patient-nurse ratio of 4:1, four nursing technicians, and a kinesiologist exclusively for the unit. Each night shift is staffed by two resident physicians, three nurses, four nursing technicians, and a kinesiologist. On weekends and holidays, both day and night shifts (non-business days) are staffed the same way as each business day night shift. Doctors, nurses, and kinesiologists are the same for day, night, and non-business day shifts. During nights and non-business days, there is a non-pediatric anesthesiologist, but there is no otolaryngologist.

Study design and subject selection

Retrospective cohort study, including patients who received invasive MV from January 1, 2018, to December 31, 2021 (48 months) at the *Hospital Dra. Eloísa*

Díaz, Santiago, Chile. Inclusion criteria were patients under 18 years of age (including neonates) intubated orally or nasally with a duration of invasive MV of at least 6 hours. Exclusion criteria were patients without attempted extubation (tracheostomy and deceased patients), subjects discharged without withdrawal of invasive MV, scheduled extubation for airway revision, new intubation scheduled for procedures, subjects in which chronic noninvasive ventilation was chosen, and palliative extubations. Only the first extubation attempt was evaluated for the analysis. Data from the primary surgical procedure were considered in cases where patients underwent multiple surgical procedures during the same hospitalization, and subsequent episodes of invasive MV following EF were not taken into account.

Figure 1 details the pharmacological protocol of analgosedation used by the PICU. The weaning process of ventilatory support and extubation decision were guided by the treating medical team according to clinical evaluation and institutional protocols. In our unit, a daily evaluation of extubation criteria is performed, and if said criteria are met, an SBT is performed to determine, together with the treating team, the optimal conditions for extubation (Figure 2).

Data collection and definitions

The data were extracted from the electronic clinical records from the hospital management computer system, both individually and manually. The data were anonymized to protect confidentiality for recording the variables.

The variables to be analyzed were age, sex, cause of connection to invasive MV, duration of invasive MV, day of the week on which extubation occurred, time of extubation, total duration of stay in the PICU, and occurrence of EF.

Extubation was defined as the removal of the artificial airway in the patient. EF was defined as endotracheal intubation within 48 hours of extubation.

The duration of invasive MV was measured in hours. PICU stay was defined as the number of days elapsed between the time of admission of the patient to the unit and discharge from it to another unit in the same hospital, another hospital, home discharge, or death.

Patients were classified into the daytime extubation (DE) group when the artificial airway was withdrawn between 08.01 and 20.00 h and nighttime extubation (NE) between 20.01 and 08.00 h. Patients were additionally classified according to the time of extubation. In addition, the patients were classified according to the nature of the day of the week on which they were extubated, being extubation on a working day (EWD) between Monday and Friday and extubation on a nonworking day (ENWD) when it was performed on Saturday, Sunday, and holidays.

Statistical analysis

The Anderson-Darling normality test was used to establish the distribution of the data. Continuous variables were expressed as median (p25 - p75), categorical variables as percentage and range or percentage, and 95% CI. For bivariate analysis, the Kruskal-Wallis

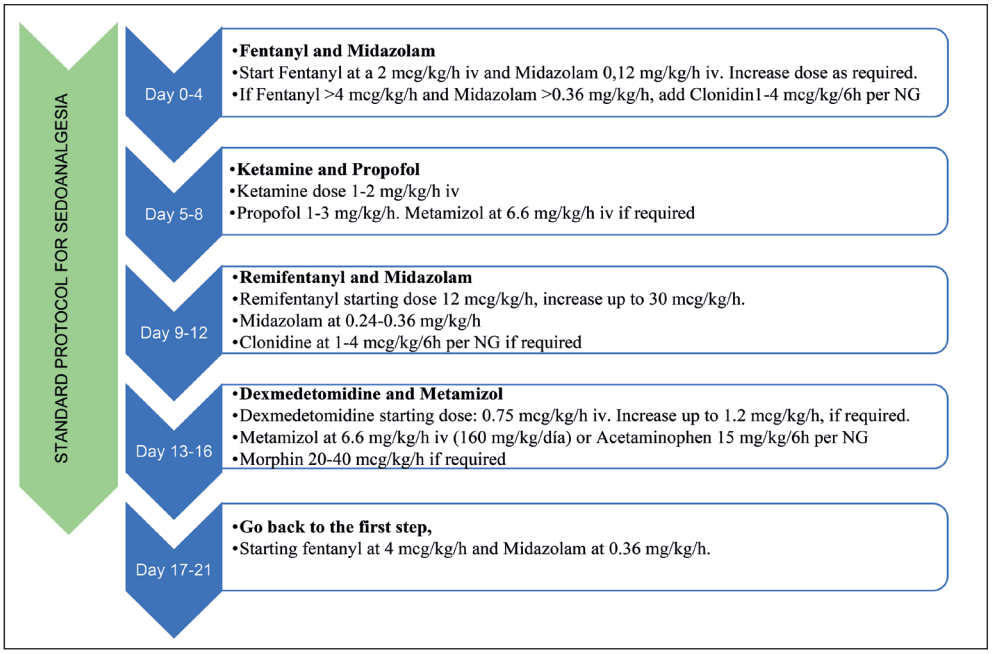

Figure 1. Standard Protocol for analgosedation in pediatric intensive care unit. *Modifed from Pediatric Crit Care Med 2019;20(12):1111-1736. Titration of sedoanalgesia must be adjusted by clinical scale (COMFORT-B, Sophia Observations Withdrawal Symptoms Scale (SOS), Cornell Assessment of Pediatric Delirium (CAPD))

test was used for continuous variables and the Chi-square test for categorical variables. A value of $p < 0.05$ was considered statistically significant.

Results

During the period analyzed, there were 1527 admissions to the PICU, of which 237 (15.5%) were ICU admissions. 196 patients received invasive MV, representing 13% of all admissions and 82% of ICU cases. Finally, 146 cases were included in the analysis. Figure 3 shows the flow chart of case selection.

58.9% of the patients were male, with a median of 1.14 (0.25-5.5) years, and 14 patients were younger than 28 days, corresponding to 9.5% of the total. The primary cause of connection to invasive MV was respiratory 38.4% (n = 56), neurological 12.3% (n = 18), sepsis 11.6% (n = 17), and post-operative 15.1% (n = 22). Of the total extubated, 85.6% were extubated to a nose piece, 4.1% were extubated to a Multi-Vent mask, 2.0% were extubated to a high-flow nasal cannula, and 8.2% were extubated to noninvasive MV.

Patients with DE accounted for 82.2% (n = 120) and those with NE for 17.8% (n = 26). Figure 4 shows the distribution according to the time of extubation. EWD patients accounted for 82.9% (n = 121) and ENWD patients for 17.1% (n = 25). Figure 5 shows the distribution according to the day of the week. The EF was 5% for those with DE and 3.8% for those with NE (p = 0.8).

Table 1 presents the bivariate analysis of DE, NE, EWD, and ENWD categories. Nocturnal extubation and the day of extubation were not associated with EF. Of the patients extubated to a nose piece, 4.8% presented EF, and 8.3% of those extubated to noninvasive MV. In the remaining patients, there was no extubation failure. There was no significant difference.

The average total duration of MV in the PICU was 78.6 hours. The duration of invasive MV to first extubation was shorter for nocturnal extubations (72.0 vs. 48.0 h, p = 0.027). There was no difference in the duration of invasive MV, whether extubation was performed on a working or non-working day (p = 0.356). There was no significant difference in length of stay in PICU between NE and DE. The length of stay in PICU was 9 (5-15.5) and 6 (4-8.5) in EWD and ENWD, respectively (p = 0.029).

Regarding age, no association was found between age and the occurrence of EF (2.62 (0.58 - 5) vs. 1.12 (0.25-5.31) years, p = 0.637).

Finally, an association was found between the duration of invasive MV and the occurrence of EF (93 (72-131) vs. 62 (40-85) h, p = 0.022).

Discussion

The multidisciplinary team in charge of the critically ill pediatric patient should always aim for a balance between decreasing the duration of invasive MV, the risk of EF, and the development of associated comorbidities[13]. However, in the systematic reviews and current recommendations of evidence-based clinical practice guidelines for the pediatric population on weaning from MV and extubation, there are no sections that

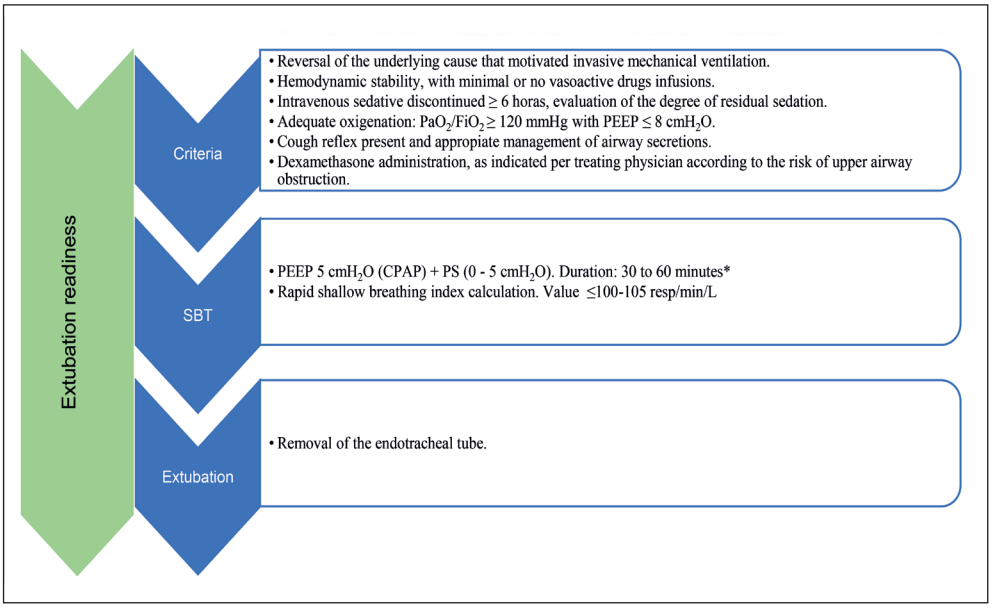

Figure 2. Extubation readiness bundle. PaO2: arterial oxygen partial pressure, FiO2: oxygen inspired fraction, PEEP: positive end-expiratory pressure, CPAP: continuous positive airway pressure, SBT: spontaneous breathing trial, PS: pressure support. *60 minutes in high-risk patients for extubation failure (myocardial dysfunction, neuromuscular disease, mechanical ventilation greater than 14 days, etc.)

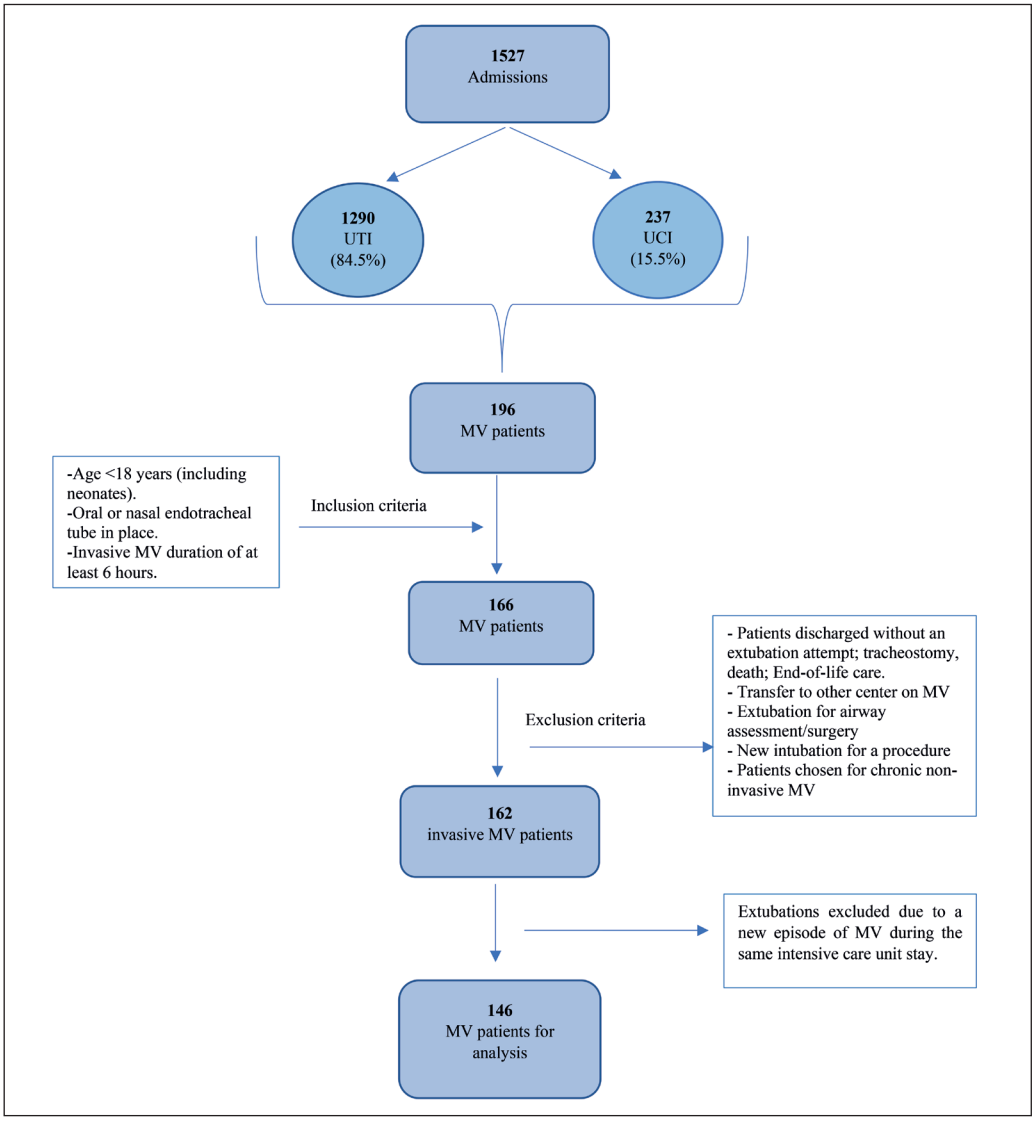

Figure 3. Patient selection diagram. UTI: intermediate care unit, UCI: intensive care unit, MV: mechanical ventilation.

particularly address the issue of nocturnal extubation in the pediatric ICU in the different health realities and at different levels of complexity[14,15].

Our cohort's observed EF rate (4.7%) is in the lower range of what is usually reported[16], and specifically within the range reported (3-8%) in Latin America[17,18]. Notably, the time at which extubation was performed (day or night) was not associated with a higher frequency of EF. Therefore, fear and/or concerns about the risk of presenting EF should not justify delaying the patient's extubation. In this regard, a recent study conducted in a developed country[10] and only one Latin American study[6] with similar results. However, currently, this practice is still not widespread, which can be corroborated in a survey of half a thousand intensivists in 47 countries regarding various conducts

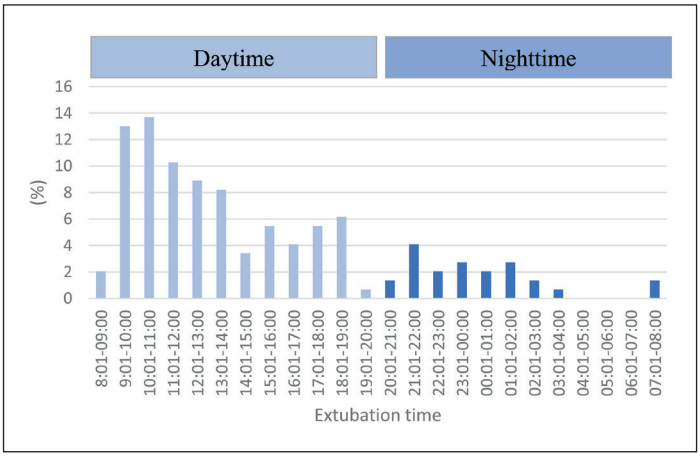

Figure 4. Relative frequency of extubation time per hour for all the cohort.

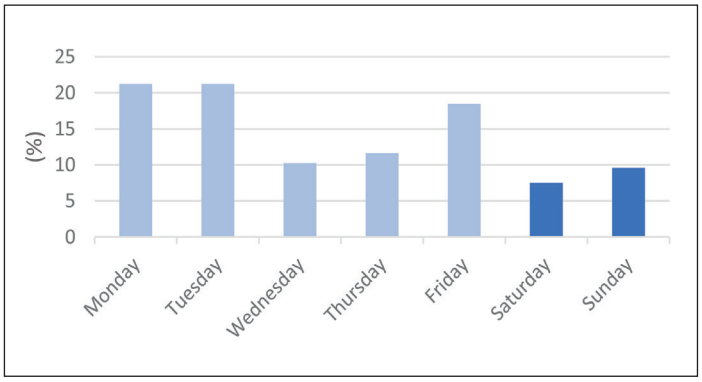

Figure 5. Relative frequency of extubations per day of the week for the whole cohort.

on MV withdrawal, where it was noted that a third of them "rarely" or "never" extubate during the night shift patients perceived by the attending physician as having a low-moderate risk of EF[18].

The percentage of invasive MV use in patients admitted to the PICU reached a lower value than that described (13%) if we consider the total number of patients; however, it was 82% when considering only those patients in ICU condition at the time of admission, which is a higher figure than usually reported[19-22]. These differences may be due, in part, beyond the local clinical practice of the treating team to the different admission criteria used in the different ICUs, each responding to its own health reality.

Although most extubations were performed during the daytime, in our study, 18% of patients underwent extubation at night. This is similar to Duyndam et al.[23] and Schults et al.[5] reports and higher than the study by da Silva et al.[6] (10%).

Regarding the day of extubation, most extubations occurred on a working day (82%), which may reflect a local reality probably more related to the availability of trained medical and non-medical resources than to the patient's condition. This is supported by the fact that the days with the lowest frequency of extubation were Saturday and Sunday (7% and 9%, respectively) and that, on the other hand, 42% of extubations occurred on the first two days of the week. In a recent communication from two developed countries, Schults et al.[5] noted the frequent perception by the nursing team of the occasional delay in extubation due to the unavailability of medical staff. In an attempt to address this aspect and to correct potential organizational barriers to the implementation of an expeditious ventilatory weaning protocol, Duyndam et al.[23,] in a prospective study, were able to almost double the rate of extubations that took place during the night (9.4% vs. 16.9%) by using a nurse-led protocol (nurse/patient ratio 1:1 or 1:2), without observing an increase in the reintubation rate or a decrease in patient safety.

Regarding the impact caused by the degree of experience or skill of the treating professional team, it has been pointed out for both the pediatric[24] and neonatal[25] populations that those patients admitted to the ICU during the weekend or at night present a higher risk of mortality, which is attributed to the different composition of the treating staff[26]. In contrast, Ianucci et al.[27] reported that having permanent nighttime co-

Table 1. Descriptive statistics and bivariate analysis for all extubations, day-shift extubations and night-shift extubations; and Working day extubation and non-working day extubation[&]

	All cohort	Day-shift extubation	Night-shift extubation	P	Working day extubation	Non-working day extubation	P
Age, years	1.14 (0.25-5.5)	1.14 (0.25-5.54)	1.1 (0.15-4.25)	0.605	1.08 (0.22-6)	1.27 (0.59-3.5)	0.651
Extubations	100 (146)	82.19 (120)	17.81 (26)		82.88 (121)	17.12 (25)	
Extubation failure	4.79 (7)	5 (6)	3.8 (1)	0.803	4.1 (5)	8 (2)	0.410
MV duration, hours	66 (42.5-92.25)	72 (48-96)	48 (24-73.5)	0.027*	72 (44-96)	57 (38-83.5)	0.356
UCIP LOS, days	8 (5-14)	7 (3.75-14)	8 (5-14.75)	0.456	9 (5-15.5)	6 (4-8.5)	0.029*

MV: Mechanical Ventilation, PICU: pediatric intensive care unit; LOS: lenght of stay. *P < 0.05. [&]Data are presented as % (n) or median (IQR).

verage by a trained staff did not benefit pediatric post-cardiac surgery patients in terms of a higher rate of NE[27]. These differences in terms of professional human resources could be why the differences between centers for the day and time when extubation is preferred.

The study showed that the duration of invasive MV was significantly shorter in patients with NE compared with those with DE, data similar to those reported by da Silva et al.[6] and Loberguer et al.[10]. This finding is relevant given the known risks and complications of prolonging invasive MV[10,1,28] and the fact that delaying extubation contributes to unplanned extubations[29].

The shorter duration of invasive MV in patients with NE can be explained by the fact that these patients were periodically evaluated for extubation through an SBT and were extubated when deemed ready. Thus, the procedure was not postponed for daytime hours. This could also be explained by the fact that those with NE presented a less severe condition (aspect not analyzed) and in whom there was a preference on the part of the treating team to extubate them, given the lower risk. There are studies in adult patients[28] where it is hypothesized that the shorter duration of MV in patients extubated during the night could be because they were post-surgical (faster weaning and less risk of EF). In our cohort, 15% of all patients connected to MV were post-surgical, and 90.9% were extubated during the daytime.

The important thing about reducing the duration of invasive MV is that it allows less and/or better use of human resources and technological equipment, which are generally in high demand[19] and scarce in low-income countries,[30,32] in addition to shortening the length of hospital stay, thus achieving a better prognosis in certain groups of patients[33]. However, in our study, we were unable to demonstrate a decrease in intra-ICU length of stay for the group of patients with NE, similar to that reported by Duyndam et al.[23]. Still, there was a significant difference between EWD and ENWD in favor of ENWD concerning the length of stay in the PICU, which reinforces the idea of extubation independent of the day of the week.

Our analysis showed a significant association between the duration of invasive MV and EF, where those patients who presented failure had a longer invasive MV period than those who did not. This finding corroborates what has been previously known[10] since among the factors that increase the risk of EF are the severity of the medical condition, longer duration of invasive MV[8,17,34], prolonged and excessive use of sedation[17], and the existence of diaphragmatic dysfunction,[35] the latter two being consequences of unnecessary prolongation of invasive MV.

The limitations to consider in this study are its retrospective design, the small sample of patients, and the fact that it was carried out in a single hospital center, reflecting our local clinical practices, particularly regarding the extubation and SBT preparation test set (which remained unchanged for the duration of the study) and, finally, that the patient profile does not consider another group with particular pathophysiological characteristics, namely cardiac surgical patients[7,8]. However, despite these limitations, it seems to be a representative sample of the reality of a general public hospital in our country and probably similar in several aspects to others in Latin America, which may be useful to other institutions when implementing their own protocols.

However, more studies are needed to address this issue to validate it in PICUs with different staffing models and of different levels of complexity.

In conclusion, in this retrospective cohort study, both NE and ENWD were not associated with EF. Also, the duration of invasive MV was shorter in patients extubated at night. The duration of the PICU stay was not affected according to the extubation schedule. Withdrawal of invasive MV should be determined by clinical factors rather than the time of day in hospitals with similar resources.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: This study was approved by the respective Research Ethics Committee, which, according to the study's characteristics, has accepted the non-use of Informed Consent.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Financial Disclosure

Authors state that no economic support has been associated with the present study.

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