

Clinical, Demographic, and Respiratory Mechanics Variables Associated With Duration of Invasive Mechanical Ventilation in Pediatric Patients in the Intensive Care Unit of a Public Hospital in Córdoba (2024-2025)

Variables clínicas, demográficas y de mecánica respiratoria asociadas a la duración de la ventilación mecánica invasiva en pacientes pediátricos en una unidad de cuidados intensivos de un Hospital Público de Córdoba (2024-2025)

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ABSTRACT

Introduction: Balancing the risks of premature extubation against the complications associated with prolonged mechanical ventilation remains a major challenge in critically ill pediatric patients.

Objective: This study aimed to analyze the relationship between clinical, demographic, and respiratory mechanics variables and the duration of invasive mechanical ventilation in a pediatric intensive care unit in Córdoba, Argentina.

Materials and methods: An observational, analytical, retrospective, longitudinal study was conducted.

Results: A total of 110 patients were included, with a median age of 1 year (IQR: 0.41-3). Males accounted for 55 % of the sample, and bronchiolitis was the primary diagnosis in 36.5 % of mechanically ventilated patients. The median duration of invasive mechanical ventilation was 8 days (IQR: 5-10), and the prolonged mechanical ventilation rate was 12 %. Female sex ($p = 0.008$), body weight ≤ 10 kg ($p = 0.003$), age < 2 years ($p = 0.01$), and driving pressure ($r = 0.19$; $p = 0.04$) were significantly associated with longer invasive mechanical ventilation duration. prolonged mechanical ventilation was not associated with age < 2 years ($p = 0.47$), body weight ≤ 10 kg ($p = 0.32$), or oxygen saturation index at admission ($p = 0.09$), but was significantly associated with mean airway pressure ($p = 0.04$).

Conclusion: Age <2 years, weight ≤ 10 kg, female sex, and driving pressure were associated with longer duration of invasive mechanical ventilation, whereas mean airway pressure was associated with prolonged mechanical ventilation. Respiratory mechanics parameters may contribute to identifying patients at risk of prolonged ventilatory support; however, prospective studies are needed to confirm these findings.

Key words: mechanical ventilation pediatric intensive care units respiratory mechanics respiratory insufficiency

RESUMEN

Introducción: Equilibrar los riesgos de una extubación prematura con las complicaciones de la ventilación mecánica prolongada en pacientes pediátricos críticamente enfermos es un gran desafío.

Objetivo: Analizar la relación entre variables clínicas, demográficas y de mecánica respiratoria con la duración de la ventilación mecánica invasiva en una unidad de cuidados intensivos pediátricos de la ciudad de Córdoba.

Materiales y métodos: Estudio observacional, analítico, retrospectivo y longitudinal.

Resultados: Se analizaron 110 pacientes, con una mediana de edad de 1 año (rango intercuartílico: 0,41-3). Un 55 % eran sexo masculino y un 36,5 % de los pacientes ventilados tenían bronquiolitis. La mediana de duración de la ventilación mecánica invasiva fue de 8 días (rango intercuartílico: 5-10) y la tasa de ventilación mecánica prolongada fue del 12 %. Se observó una asociación significativa entre el sexo femenino ($p = 0,008$), el peso ≤ 10 kg ($p = 0,003$), la edad <2 años ($p = 0,01$) y la driving pressure ($r = 0,19$; $p = 0,04$) con una mayor duración de la ventilación mecánica invasiva. La ventilación mecánica prolongada no se asoció con la edad <2 años ($p = 0,47$), el peso ≤ 10 kg ($p = 0,32$) ni con el índice de saturación de oxígeno al ingreso ($p = 0,09$), pero sí con la presión media de la vía aérea ($p = 0,04$).

Conclusión: La edad <2 años, el peso ≤ 10 kg, el sexo femenino y la driving pressure se asociaron con una mayor duración de la ventilación mecánica invasiva, mientras que la presión media de la vía aérea se relacionó con la ventilación mecánica prolongada. Los parámetros de mecánica respiratoria podrían contribuir a identificar pacientes con riesgo de soporte ventilatorio prolongado, aunque se requieren estudios prospectivos que confirmen estos hallazgos.

Palabras clave: ventilación mecánica unidades de cuidados intensivos pediátricos mecánica respiratoria insuficiencia respiratoria

INTRODUCTION

Invasive mechanical ventilation (IMV) is one of the most common interventions in Pediatric Intensive Care Units (PICUs). However, prolonged use is associated with various complications, including increased length of hospital stay, morbidity, mortality, and health care costs.^{1,2}

Mechanical ventilation weaning and extubation are critical steps in patient recovery; nevertheless, these processes carry significant risks. Finding a balance between the dangers of premature extubation –such as extubation failure and the need for emergency reintubation– and the risks associated with PMV remains a challenge.

Approximately 30% of patients experience difficulty while weaning from mechanical ventilation,

which is associated with increased mortality.⁴ Although no universally accepted definition of PMV in children has historically existed, recent international initiatives have sought to standardize this terminology. In particular, the Pediatric Acute Lung Injury and Sepsis Investigators (PALISI)⁵ and LongVentKids⁶ have proposed defining PMV as mechanical ventilation exceeding 14 days, though widespread adoption of this definition has not yet been achieved. Conversely, other studies over the years have defined PMV as a duration exceeding 96 hours,^{7,9} days,² or more than 21 days.⁸ Furthermore, PMV has been linked to ventilator-associated pneumonia, pulmonary hemorrhage, tracheal injury, diaphragmatic atrophy, neuromuscular disorders, and increased PICU length of stay.⁹

Although international studies have explored clinical and epidemiological factors predisposing pediatric populations to longer durations of IMV,² few studies have evaluated these characteristics in Argentina, particularly within the province of Córdoba. Furthermore, no published studies to date have evaluated the association between duration of IMV and respiratory mechanics variables in critically ill pediatric patients. Therefore, this study aimed to analyze the relationship between clinical, demographic, and respiratory mechanics variables and IMV duration in the PICU at the Hospital Infantil Municipal in Córdoba, Argentina, between May 2024 and September 2025.

MATERIALS AND METHODS

An observational, analytical, retrospective, longitudinal study was conducted. The study included all patients requiring IMV who were admitted to the PICU at the Hospital Infantil Municipal, aged 28 days through 15 years, 11 months, and 29 days, from May 2024 to September 2025.

Patients whose medical records contained incomplete data or inconsistencies in the variables required for analysis were excluded. We also excluded children and adolescents with preexisting complex chronic comorbidity—such as neuromuscular and/or neuromotor disorders, congenital heart disease, immunodeficiencies, or rheumatologic diseases—that could alter or complicate the interpretation of results. This occurs because in patients with chronic condi-

tions, specific or adapted mechanical ventilation strategies tailored to compromised organ systems are frequently required, which could confound variables such as mean mechanical ventilation duration and respiratory system airway pressures.

The following variables were recorded:

- Clinical and demographic variables: Age (in months); sex (female, male); predicted body weight (PBW, in kg) –calculated using the McLaren method for ideal body weight. This method is based on validated growth charts that compare a child's weight and height with age-specific values at the 50th percentile;¹⁰ medical diagnosis.
- Results: Duration of invasive mechanical ventilation until successful extubation; rate of PMV; tidal volume; positive end-expiratory pressure (PEEP); fraction of inspired oxygen (FIO₂); peak inspiratory pressure (PIP); plateau pressure (Pplat); driving pressure (DP); mean airway pressure (MAP); airway resistance (Raw); static compliance (Cstat), and oxygen saturation index (OSI).

Ventilatory parameters prescribed by the PICU team at the Hospital Infantil Municipal were obtained directly from mechanical ventilators (TECME, Neumovent Advance, and Brina) and recorded by the Department of Physical Therapy in monitoring sheets 3 times daily (at 08:00, 18:00, and 23:00): PIP, MAP, PEEP, FiO₂, tidal volume.

For variables requiring specific measurement maneuvers, such as Pplat, Cstat and Raw, recording was performed under quiet breathing conditions, ensuring measurements were taken during neuromuscular blockade or in the absence of spontaneous breathing efforts above the set respiratory rate. These variables were obtained using a standardized 0.5-second inspiratory pause pre-programmed into the TECME mechanical ventilators.

Measurements obtained during maneuvers with documented air leaks exceeding 10% were excluded from data analysis. Likewise, measurements in which the measured respiratory rate exceeded the set respiratory rate were excluded, as this indicated spontaneous patient respiratory effort.

Remaining variables were extracted from patient medical records and the monitoring sheets completed by the physical therapy staff.

Categorical variables were presented as absolute frequencies and percentages. Continuous variables that assumed a normal distribution were reported as mean and standard deviation (SD). Non-normally distributed variables were expressed as median and interquartile range (IQR). Distribution normality for each variable was assessed using the Shapiro-Wilk test, given the sample size. Spearman or Pearson tests were used to assess correlations, and the Student t test for independent samples. The Mann-Whitney U test was used to assess statistically significant differences, as appropriate. Statistical significance was set at $p < 0.05$. The statistical analysis was performed using InfoStat®.

This study represents a secondary data analysis from a primary research protocol approved by the Institutional Ethics and Research Committee on December 18, 2025 (RePis No. 074/25), with the title: "Monitoreo de la Mecánica Respiratoria en Pacientes Pediátricos Bajo Ventilación Mecánica Invasiva en una Unidad de Cuidados Intensivos en un Hospital Público de la Ciudad de Córdoba [2024-2025]: Estudio Descriptivo." Monitoring of respiratory mechanics is a routine, standardized clinical practice performed by the physical therapy team for patients admitted to our PICU at the Hospital Infantil Municipal. To conduct a retrospective analysis of these variables using medical records, approval was obtained from the institutional Ethics and Research Committee for the aforementioned study, which provided a general descriptive analysis of respiratory mechanics monitoring in this cohort. Because this study was observational and based exclusively on retrospective medical record review, the Ethics and Research Committee granted a waiver of informed consent. Thus, for the present study, we used the database generated in said research, from which the variables of interest were selected and the corresponding statistical analyses were conducted, with the aim of exploring associations between different previously studied variables.

Patient confidentiality was strictly protected through data anonymization; and records were accessed solely for research purposes. This study

was conducted in accordance with the Guidelines of the Declaration of Helsinki and Good Clinical Practice, with strict protection of patient confidentiality.

RESULTS

The study population included 128 patients admitted to and monitored by the Physical Therapy Department at the PICU. The final study sample was 110 patients (Figure 1). The clinical and demographic main characteristics are presented in Table 1. Notably, for patients who developed secondary or co-occurring diagnoses during their clinical course, both diagnoses were included in the analysis (e.g., patients initially intubated for respiratory distress secondary to acute bronchiolitis who subsequently developed acute respiratory distress syndrome [ARDS] or shock).

Female sex ($p = 0.008$), weight ≤ 10 kg ($p = 0.003$), and age < 2 years ($p = 0.01$) showed a statistically significant association with a longer duration of IMV. A weak but statistically significant positive correlation was observed between higher DP and longer IMV duration in the study cohort ($r = 0.19$; $p = 0.04$) (Figure 2). Furthermore, patients weighing < 10 kg and infants aged < 2 years exhibited worse RM parameters compared to the remaining population, as detailed in Table 2.

If we analyze the overall sample, we can observe that PMV was not associated with age under 2 years ($p = 0.47$), weight < 10 kg ($p = 0.32$), or oxygenation severity measured by OSI upon admission ($p = 0.09$), although a statistically significant association was found with MAP ($p = 0.04$).

Patients with longer duration of IMV more frequently required post-extubation NIV compared to those who received IMV for fewer days ($p = 0.003$). On the other hand, patients who developed ARDS presented significantly higher OSI values upon admission, with a median of 8.61 (IQR 6.89-9.69).

DISCUSSION

The present study identified associations between several clinical, demographic, RM variables and the duration of IMV among critically ill pediatric patients admitted to the Hospital

Figure 1. Diagram showing the selection of patients included in the study

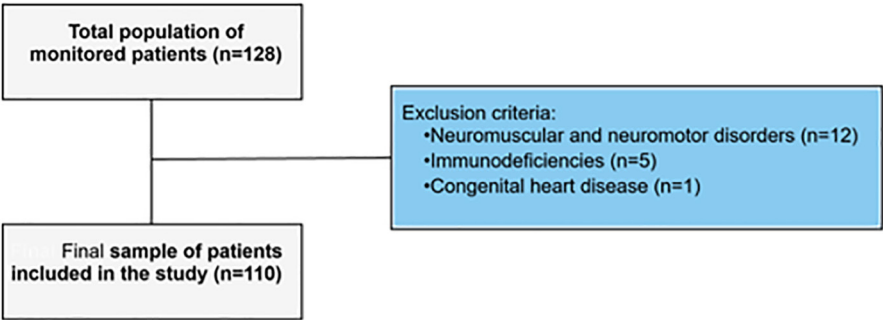


Table 1. Clinical and Demographic Characteristics of Pediatric Patients Admitted to the PICU During the 2024-2025 Period (n=110)

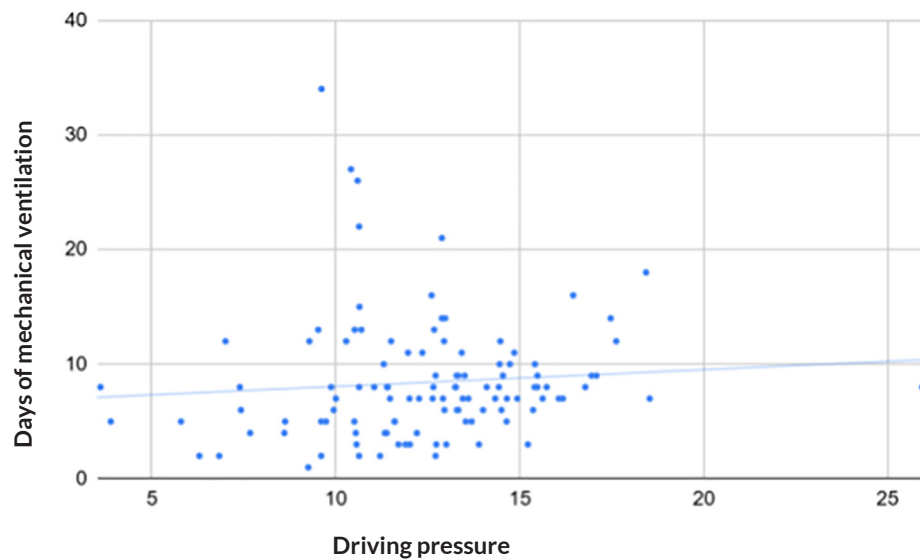
Age (years), median (IQR)	1 (0.41-3)
Sex, n (%)	Female, 50 (45) Male, 60 (55)
Weight (kg), median (IQR)	10 (7-15)
Diagnosis, n (%)	Bronchiolitis, 46 (36.5) Lower airway obstruction, 23 (18.3) Pneumonia, 14 (11.1) Asthma exacerbation, 13 (10.3) Severe acute respiratory distress syndrome, 5 (4) Postoperative abdominal surgery, 5 (4) Postoperative neurosurgery, 4 (3.2) Septic shock, 5 (4) Other, 11 (8.7)
Days of invasive mechanical ventilation, median (IQR)	TTotal, 8 (5-10) Bronchiolitis, 8 (6-9) Lower airway obstruction, 9 (8-13) Asthma exacerbation, 6 (4-12) Septic shock, 6 (5-8) Acute interstitial pneumonia, 9 (7-11) Severe acute respiratory distress syndrome, 18 (12-21) Other, 4 (2-5)
Prolonged mechanical ventilation (>14 days), n (%)	13 (12 %)

Infantil Municipal de Córdoba over a 16-month period.

Factors associated with noninvasive mechanical ventilation failure,¹¹ as well as those related to extubation failure^{12,13} have received increasing attention in the national literature in recent years. However, when examining factors associated with IMV duration, comparisons across studies are more challenging. This is due, on the one hand, to the limited number of studies that have specifically addressed this outcome in the pediatric population in our country and, on the other, to the lack of universal consensus regarding the de-

finition of PMV, which limits comparisons among available studies.

Several studies have proposed different cutoff points for defining PMV, including the need for mechanical ventilation for >21 days and/or >6 hours per day, with a reported prevalence of approximately 5%,⁸ whereas others have used longer duration thresholds, such as >9 days or 96 hours, reporting PMV rates of approximately 22.5% and 50%, respectively. 2,5 More recently, initiatives such as LongVentKids⁹ and leading pediatric mechanical ventilation groups, including PALISI,⁶ have promoted the standardization of

Figure 2. Correlation between days of mechanical ventilation and driving pressure in patients at the PICU (n=110)**Table 2.** Respiratory Mechanics Values by Patient Group (N = 110)

Variables	Sex distribution		p-value	Weight distribution		p-value	Age distribution ^d		p-value
	F (n = 50)	M (n = 60)		<10kg (n = 65)	≥10kg (n = 45)		<2 years (n = 77)	≥2 years (n = 33)	
PIP (cmH ₂ O) Median, SD	22.08. 3.01	21.13. 2.45	0.12	22.03. 2.45	20.88. 3.02	0.04	21.62. 2.54	21.43. 3.21	0.65
Pplat (cmH ₂ O) Median, SD	17.94. 3.29	18.31. 7.16	0.85	18.42. 2.95	17.75. 8.24	0.001	18.09. 2.90	18.26. 9.55	0.03
FIO ₂ Median, SD	0.52. 0.07	0.53. 0.06	0.31	0.54. 0.06	0.51. 0.07	0.01	0.53. 0.06	0.51. 0.07	0.20
MAP (cmH ₂ O) Median, SD	10.01. 1.32	9.91. 1.53	0.78	9.82. 1.39	10.15. 1.48	0.21	9.81. 1.36	10.29. 1.56	0.06
Expiratory Raw (cmH ₂ O/L, sec) Median, SD	57.15. 25.65	55.78. 27.25	0.55	68.65. 23.97	38.71. 18.77	<0.0001	66.44. 23.95	32.98. 14.40	<0.0001
Cstat (ml/ cmH ₂ O) Median, SD	8.79. 5.57	8.96. 6.84	0.88	5.24. 2.24	14.14. 6.48	<0.0001	5.81. 2.67	16.03. 6.44	<0.0001
DP (cmH ₂ O) Median, SD	13.09. 3.15	11.99. 3.05	0.17	13.11. 3.35	11.60. 2.56	0.001	12.84. 3.24	11.68. 2.72	0.03

the definition of PMV, defining it as the need for IMV for >14 days and/or >6 hours per day, with reported PMV prevalence ranging from 10% to 33%.^{7,9,14}

Using this definition, 12% of patients in our study required PMV. In addition, no statistically significant association was observed between PMV

and the severity of oxygenation impairment at admission, as assessed by the oxygenation saturation index (OSI) (p= 0.09). Previous studies have reported a significant association between illness severity upon PICU admission, as assessed by the Pediatric Index of Mortality 3 (PIM-3), and the presence of PMV.⁷

Also, a statistically significant association was observed between female sex ($p=0.008$), body weight ≤ 10 kg ($p=0.003$), age <2 years ($p=0.01$), and DP ($p = 0.04$) and longer duration of IMV. Previously described factors in the literature associated with longer duration of mechanical ventilation include weight <10 kg, age <12 months, and DP >13 cm H₂O during the first day of ventilatory support.¹⁵ In addition, higher DP values have been independently associated with a longer time to extubation in mechanically ventilated pediatric patients.¹⁶

Interestingly, although age <2 years and weight ≤ 10 kg were associated with a longer duration of IMV in our study population, when PMV was analyzed as a dichotomous outcome (IMV >14 days), no significant association was observed with age <2 years. These findings suggest that factors associated with an increase in the number of mechanical ventilation days do not necessarily overlap with those associated with the development of PMV. Although younger age, and consequently lower weight, appear to influence the duration of ventilatory support, neither factor was associated with PMV in our cohort. This discrepancy may be related, at least in part, to the heterogeneity that persists in the definition of PMV in pediatric patients, as the different cutoff points used across studies may influence the associations observed. In contrast to our findings, a previous study identified age <6 months as a factor associated with PMV,² whereas other investigators reported an association between PMV and age <2 years.⁵

MAP reflects the intensity of ventilatory support and serves as an indicator of the severity of impaired gas exchange, influencing both arterial oxygenation and the hemodynamic impact of positive-pressure ventilation in critically ill pediatric patients. Although it is continuously displayed on most ventilators and does not require specific maneuvers for its calculation, MAP remains an underused parameter in RM monitoring.¹⁷ Unlike Pplat or DP, which assess the inspiratory phase exclusively, MAP integrates both phases of the respiratory cycle. Therefore, it is sensitive to

changes in airway resistance, lung and chest wall compliance and increases in work of breathing. At the same time, MAP, together with FiO₂ and PaO₂, is used to calculate the oxygenation index. Ventilation using high MAP values, regardless of improvements in oxygenation, is associated with overdistension, an increased risk of pulmonary stress and strain, and hemodynamic impairment due to reduced venous return and compromised right ventricular function. Although there is no universally accepted cutoff point for MAP, some authors have proposed reference ranges of 2 to 8 cm H₂O as normal values, 10 to 20 cm H₂O in patients with obstructive airway disease, and 15 to 30 cm H₂O in patients with acute respiratory distress syndrome.

18. In our cohort, MAP was significantly associated with the presence of PMV ($p = 0.04$). This finding is consistent with a recent study² that reported an association between MAP >13 cm H₂O and a higher likelihood of PMV, defined in that study as IMV for >9 days.

This study has several strengths, including the simultaneous assessment of demographic, clinical, and MR variables, which allowed for a comprehensive evaluation of factors associated with the duration of IMV in this population. In addition, to our knowledge, this is the first study conducted locally to address this topic, providing relevant evidence to improve our understanding of the factors associated with the duration of ventilatory support in critically ill pediatric patients in our region. Among the limitations, several factors potentially associated with IMV duration were not included, such as sedation strategies, delirium screening, the degree of intensive care unit-acquired weakness, and infectious complications during hospitalization. In addition, illness severity scores at PICU admission, such as PIM-3 or PRISM, were not incorporated, limiting the assessment of other potential associations with PMV. Furthermore, the findings of this study should be interpreted with caution, as the observed associations were based on unadjusted analyses. Prospective studies are needed to confirm these findings and to more precisely identify the factors associated with the outcomes evaluated.

CONCLUSIONS

Age <2 years, weight ≤ 10 kg, female sex, and DP were associated with longer duration of IMV, whereas MAP was associated with PMV. These findings highlight the potential value of MR parameters as tools for the early identification of pediatric patients at increased risk of requiring prolonged ventilatory support, although prospective studies are needed to confirm these findings.

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Conflict of interest

Authors have no conflicts of interest to declare.

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