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ORIGINAL ARTICLE

Magnitude of Extubation Failure in Mechanically Ventilated Cases at Pediatric Intensive Care Unit at Aswan University Hospital

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ABSTRACT

Keyword: Extubation Failure, Mechanically Ventilated.

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Background: Around fifty-five percent of pediatric intensive care unit (ICU) admissions necessitate mechanical ventilation (MV). The extubation and intubation of such cases are significant risks and may correlate with elevated morbidity and mortality rates. **Aim:** To assess the magnitude of extubation failure of mechanically ventilated cases admitted to pediatric ICU at Aswan University Hospital and to study different factors related to extubation failure. **Methodology:** This research has performed in the PICU of the Pediatric Department at Aswan University Hospital, over a six-month period from June 2022 to December 2022. All admitted cases in this period have been involved in the research. **Results:** This research analyzed 50 pediatric ICU cases, of which 20 (40%) experienced extubation failure. No significant differences were found in sex, age, or diagnosis. Extubation failure was significantly associated with intubation >1 week (73.91%, p<0.001), hospital stays >2 weeks (62.5%, p=0.03), absence of pre-extubation steroids (80%, p<0.001), VAP (82.35%, p<0.001), positive CRP (70.83%, p<0.001), ETT/blood culture growth (92.31%, p<0.001), severe oxygenation index (p=0.006), mechanical complications (p=0.002), cardiopulmonary arrest (p=0.006), electrolyte imbalances (p<0.001), and sedation >5 days (76.19%, p<0.001). Pre-extubation steroid use and addressing risk factors may reduce extubation failure. **Conclusion:** Extubation failure is linked to prolonged intubation, hospital stay, VAP, mechanical complications, high oxygenation index, sedation, electrolyte imbalance, and cardiopulmonary arrest; corticosteroids may help prevent it.

INTRODUCTION

Around fifty-five percent of ICU admissions need mechanical ventilation [(1)].
The intubation and extubating of these cases are significant risks and might correlate with elevated mortality and morbidity [(2)].
Multiple factors contribute to this increase, including essential ventilatory parameters and the length of MV [(3)].
Although mechanical ventilation provides advantages when appropriately indicated, its extended application may lead to airway injuries, cardiovascular instability, lung infections, and problems associated with immobility. [(4)].

Comparably, premature EXT can also be harmful due to failure and the need for reintubation are related to prolonged stay at hospital and neurological and/or cardiorespiratory impairments, which can result in prolonged disability [(5)].

The most recent edition of the Brazilian Guidelines for MV defines extubation failure as the necessity for reintubation within forty-eight hours following the removal of artificial airway. In the pediatric demographic, the failure rate is predicted to be between sixteen percent and twenty-two percent [(6)].

The determination of the optimal timing for extubation is a difficulty and is usually determined by clinical judgment, considering the case's neurological, cardiorespiratory, and hemodynamic status [(7)].

Consequently, carrying out of a well-defined extubation readiness protocol is very important [(8)].

The Pediatric Acute Respiratory Distress Syndrome: Consensus (PARDS) advises conducting daily assessments of extubation readiness in pediatric cases [(9)].

Prior to 2017, the Recommendations for Mechanical Ventilation of Critically Ill Kids from the Paediatric Mechanical Ventilation Consensus Conference lacked consistent information demonstrating that any device or test for predicting failure was greater than clinical assessment. Consequently, no procedure has been recommended for determining extubation readiness. [(10)].

Aim of work: To evaluate the incidence of extubation failure of mechanically ventilated cases admitted to pediatric intensive care unit at Aswan University Hospital To study different factors related to extubation failure.

PATIENTS AND METHODS

This prospective cohort research has been carried out in pediatric ICU, Pediatric department, Aswan University Hospital, Aswan, Egypt. over 6-month duration, from June 2022 to December 2022.: All cases admitted in this period and connected to mechanical ventilation, aged one month to fifteen years with mechanical ventilation dutation 24 hours or more were included in the study. On the other hand, patient with accidental extubation, patient undergoing tracheostomy and patient died before first extubation were excluded

procedure: ***The eligible subjects involved in this research have been exposed to the following:***

- Informed consent has been achieved from care givers of the participants before beginning, after explaining the objective of the study, the type of operation, the possibility of complications, and the potential benefits.
- Full history including: age, weight & gender, chronic or recurrent chest disease, underlying cardiac disease, underlying neuromuscular disease, renal disease, haematolgical disease, gastrointestinal disease & endocrinal disease and history of present illness, duration of pediatric intensive care unit admisson, duration of intubation, prolonged steroid adminestration, steroid adminestration before extubation, prolonged sedation, cardiopulmonary arrest during course of intubation. Features of sepsis and Ventilatory Acquired pneumonia (VAP) before and after intubation
- . Clinical examination including**:** all participants have been exposed to complete physical examination involving evaluation of the general condition and vital signs as blood pressure, heart rate, respiratory rate and Random blood Glucose, cases have been categorized into subgroups according to the primary diagnosis on admission to the pediatric intensive care unit. Respiratory cases involved those with pneumonia, asthma, bronchiolitis, and acute respiratory distress syndrome; neurologic patients included those with seizures, encephalitis, congenital myopathy, and meningitis; and cardiac patients included those with congenital heart disorder, myocarditis, and myocardiopathy. Renal patients incorporate those with acute and chronic renal

failure and other renal diseases; patients with Gastrointestinal tract diseases, Haematological diseases and endocrinal diseases.

- Investigations: ***Laboratory investigations:*** 5 millimeters was drawn from each patient once and complete blood count, Random blood glucose, Arterial blood gases, serum sodium, serum potassium, serum magnesium, serum calcium, serum phosphorus, C-reactive protein were done at first day of intubation, after 48 hours, at day of extubation and at day of reintubation, endotracheal swab culture and blood culture were done at first day of intubation, after 48 hours, at day of extubation and at day of reintubation
- Radiology: Chest X-ray was performed on all patients at first day of intubation, after 48 hours, at day of extubation and at day of reintubation.
- Evaluation of ventilatory acquired pneumonia**:** amount and type of secrtions (massive and purulant secretion indicate VAP), presence of fever (high grade fever indicate VAP) and endotracheal swab culture and blood culture (positive or negative) **(11)**..
- Calculation of oxigenation index done on the first day of intubation Oxygenation index is calculated as OI = MAP × Fio2 × 100 / Pao2, where MAP indicates mean airway pressure and Fio^2 indicates fraction of inspired oxygen**(12)**.
- The decision to extubate, after weaning protocol, involved several largely subjective evaluations: resolution or development of the underlying illness, intact respiratory drive, minimal sedation effects from medications, adequate cough reflex for secretion clearance, sufficient spontaneous gas exchange as indicated by blood gas analysis, oxygen saturation, as well as FIO2 requirements ≤0.40, negative inspiratory force below thirty centimeters water (measured with a handheld manometer), and vital capacity above ten milliliters per kilogram (assessed with a Wright spirometer). Additionally, clinical evaluations of mechanics, hemodynamic status, and respiratory rate, as well as well-compensated metabolic stability, have been carried out primarily on neuromuscular cases capable of cooperation. Steroids have been provided pre-extubation at the discretion of the attending pediatric intensivist**(13)**.
- Failed extubation is defined as a return of an endotracheal tube within forty-eight hours following an extubation attempt**(14)**. The failure extubation rate was determined by dividing the number of initial failed extubations by the total number of initial extubation trials and multiplying the result by one hundred. Reintubation has been executed at the attending intensivist's discretion. Reintubation typically occurred due to a lack of oxygen and/or ventilation, as determined by clinical evaluation of work of breathing, blood gas analysis, failure to sustain an upper airway edema, or patent airway.
- Cases on mechanical ventilation were assessed daily until one of four objectives was reached: 1) Two days of post-extubation. 2) Two days after the move to an intermediate care level within the same facility. 3) Discharge from the pediatric intensive care unit to home or transfer to another institution (inpatient rehabilitation or another pediatric intensive care unit). 4) Death. Cases who were reintubated within forty-eight hours of extubation have been evaluated as a singular mechanical ventilation event. Outcome measures were rates of failed extubation, length of hospitalization, the length of mechanical ventilation in hours, requirement for tracheostomy, and hospital death rates.

Ethical Consideration: ***Confidentiality:*** The confidentiality of all participants was fully protected possible. The study participants were identified by name in any report or publication resulting in being admitted to this study from data collected in this study.

Research statement: This investigation involved ethical problems, both substantial and procedural. Prior to the admission of participants into this trial, the objectives, nature, and associated risks have been explained to the cases. Participants must acknowledge their comprehension of the investigational nature of the research, its associated risks and benefits, their right to opt out in participation without compromising their access to appropriate healthcare at the research site, the

chosen contact for questions about the research, and that they have freely given informed consent for participation in this research.

Informed consent: The signed informed consent form was permanently incorporated into the participant's research records and has been preserved in the same manner as other records.

Time schedule

Topic	**Period(month)**
Preparatory phase	1
Design of examination sheet	1
Review of literature	2
Collection, organization, entering of data and statistical analysis	2

Data management and Statistical Analysis: Historical data has been gathered, fundamental clinical assessments have been executed, laboratory tests have been carried out, and outcome measures have been encoded, documented, and analyzed utilizing Microsoft Excel software.

The data were subsequently imported into the Statistical Package for the Social Sciences (SPSS version 20.0) for analysis. Qualitative data is represented as numbers and percentages, while quantitative data is expressed as mean ± standard deviation. The following tests have been utilized to assess significance: Pearson's correlation or Spearman's correlation for correlation analysis.

P- value: level of significance: P-value below 0.05: Significant (S). P-value above 0.05: Non-significant (NS). P-value below 0.01: Highly significant (HS).

Descriptive statistics: Standard deviation (± SD), Mean and range for parametric numerical data, while Inter-quartile range (IQR) and Median for non-parametric numerical data.

Percentage and frequency of non-numerical data.

Analytical statistics: Kruskal-Wallis test has been utilized to assess the statistical significance of the distinction of a non-parametric variable among above two study groups.

RESULTS

Table(1)): Duration of intubation in the studied cases.

Duration of intubation				**P value**
	Total number	**Extubation failure**	**Percentage%**	
Less than or equal 1wk	27	3	11.11%	P<0.001*
More than 1wk	23	17	73.91%	
total number	50	20	40%	

. * p< 0.05 is statistically significant.

Table (2): Duration of hospital stay in the studied cases.

Duration of hospital stay				
	Total number	**Extubation failure**	**Percentage %**	**studied cases**
Less than 0r equal 2wks	26	5	19.23	P=0.003*
More than 2wks	24	15	62.50	
total number	50	20	40%	

Table (3): Ventilatory acquired pneumonia(VAP) assessment of the studied cases

VAP assessment				
	Total number	**Extubation failure**	**Percentage**	**P-value**
Cases Acquired vap	17	14	82.35	P<0.001*
Cases Not acquired vap	33	6	18.18	
Total number	50	20	40%	

VAP: ventilation associated pneumonia. * p< 0.05 is statistically significant.

Table (4): Oxygenation index among the studied cases

Oxygenation index				
	Total number	**Extubation failure**	**Percentage**	**P-value**
Mild HRF OI 4-8	20	6	30.00 %	P=0.006*
Moderate HRF OI 9-16	24	8	33.33 %	
Severe HRF >16	6	6	100.00 %	
Total number	50	20	40%	

Table (5): Complication of mechanical ventilation (subglottic edema & laryngeal edema) in the studied cases

Complication of mechanical ventilation				**P value**
	Total number	**Extubation failure**	**Percentage %**	
Yes	**6**	**6**	**100**	**P=0.002***
No	**44**	**14**	**31.82**	
Total number	**50**	**20**	**40%**	

Table(6) Laboratory investigations at day of extubation in the studed cases.

Laboratory investigations at day of extubation				**P-value**
Electrolyte imbalance				
	Total number	**Extubation failure**	**Percentage**	
With electrolyte imbalance	**19**	**14**	**73.68%**	**P<0.001***
Without electrolytes imbalance	**31**	**6**	**19.35%**	
Total number	**50**	**20**	**40%**	

Table (7): Prolonged sedation among the studied cases

Prolonged sedation				**P-value**
	Total number	**Extubation failure**	**Percentage**	
Less than 5 days	29	4	13.79	P<0.001*
More than 5 days	21	16	76.19	

DISCUSSION

Our prospective cohort research aimed to assess the incidence of extubation failure in mechanically ventilated cases (n=50) admitted to PICU at Aswan University Hospital over 6 month duration, from June 2022 to December 2022 and to study different factors related to extubation failure.

We calculated the duration of intubation, which were less than or equal 1wk in 27 cases of examined cases and more than 1wk in 23 cases of examined cases. In the extubation failure group, the number of cases with intubation for more than one week was significantly higher 17 (73.91%) compared to those who were intubated for less than 1 week 3 (11.11%) there was statistically significant variance according to the duration of intubation statistically significant variance regarding the length of intubation ($p < 0.001$).

In terms of the duration of hospital stay, it were less than or equal 2wk in 26 cases of studied cases and more than 2wk in 24 cases of studied cases, respectively. In the extubation failure group, the number of cases with hospital stay for more than two weeks was significantly higher 15(62.5%) compared to those with hospital stay for less than 2 weeks 5 (19.23%)there was statistically significant difference regarding the duration of hospital stay ($p= 0.03$).

Consistent with our findings, **Heubel et al.** [15] noted that longer stays in the ICU ($p=0.000$) and hospital ($p=0.010$) correlated with a heightened an opportunity of extubation failure.

Consistent with our predictions, the primary predictors of planned extubation failure detected in a recent investigation by **Thille et al.** [16] were also recognized as risk factors for extubation failure in the current research: mechanical ventilation length exceeding one week before extubation, ineffective cough, as well as severe systolic left ventricular dysfunction.

Consistent with our findings, ***Johnston et al.*** [17] reported that extubation failure transpired in six (fifteen percent) of the 40 extubated infants. The relative age, weight, and duration of MV for the extubation-failure and extubation-success groups were as follows: age 5 (3-8) months versus 4 (4-6) months ($P = .87$), weight 4 (3-5) kilograms versus 6 (5-7) kilograms (P-value below.001), and MV days 8 (6-23) Vs 6 (5-12).

Baisch et al. [18] ensured our results and concluded that PICU cases with failed extubation have longer hospitalization.

The total number of cases with VAP were 17 of them 14 cases failed to be extubated.

In the extubation failure group, the number of cases who had ventilatory acquired pneumonia (VAP) was significantly higher 14(82.35%) compared to those who not have VAP 6 (18.18%) there was statistically significant distinction regarding VAP ($p < 0.001$). In addition, **Dries and colleagues** [19]found an increased incidence of VAP in patients who failed extubation

The oxygenation index was Mild HRF OI 4-8, moderate HRF OI 9-16, Severe HRF >16 in 20, 24, and 6 patients, correspondingly. There was statistically significant variation in the oxygenation index among the extubation failure cases ($P= 0.006$) of them 6cases show Mild HRF OI 4-8,8 cases show moderate HRF OI 9-16 and 6cases show Severe HRF >16.

Our results were in coincidence with Studies utilizing OI as a predictor of extubation failure have been initiated by ***Fontela et al.*** [20]**,** who enrolled 124 children intubated for at least 12hours and found that OI > 5, was a risk marker for extubation failure.

In the extubation failure group, cases with mechanical complications were significantly higher 6 (100%) (4 of them complicated with laryngeal edema & 2 of them complicated with subglottic edema) compared to those with no Mechanical complications14 (31.82%). there was statistically significant difference regarding mechanical complication ($p<0.002$). In agreement, ***Heubel et al. (2020)***[15] noted that the main cause attributed to extubation failure was laryngeal stridor (subglottic edema in our results) with totaling 57% of the 89 cases. He concluded that laryngeal stridor was responsible for more than half of cases of extubation failure.,

In line with our risk factors, a previous recent study in 2023 collected 318 extubation events from 246 patients. Of these, 35 (11%) events were extubation failures. The predictive factors associated

with extubation failure included a history of pneumonia before extubation and stridor after extubation ***(Saengsin et al, 2023)*** [21].

Regarding the laboratory investigations, the extubation failure cases with electrolyte imbalance 14 (73.68 %) (5 0f them suffering from hypomagnesmia, 4 of them suffering from hypophosphatemia, 2 of them suffering from hyponatremia, 2 of them suffering from hypokalemia,1 of them suffering from hypocalcemia) were significantly higher than those without electrolyte imbalance 6 (19.35%) there was statistically significant difference regarding electrolyte imbalance (p <.001).

Previous laboratory research results indicate that electrolyte imbalance is a risk factor for extubation failure. ***Alsumrain et al***. [22] verified the association among hypophosphatemia and weaning failure in cases within two medical intensive care units, concluding that hypophosphatemia correlates with failure to wean from mechanical ventilation in cases in intensive care units receiving ventilatory support.

In the extubation failure group, the number of cases with prolonged sedation for more than 5 days was significantly higher 16(76.19%) compared to those with sedation less than 5 days 4(13.79%), while in the all cases, 29 patients had more than 5 days. there was statistically significant difference regarding prolonged sedation (p <.001).

Similarly, a previous study by ***Fontela et al.*** [20] aimed to describe the incidence of extubation failure and its associated risk factors among mechanically ventilated children. ***Fontela et al.*** [20] determined that extubation failure occurred more frequently in young children who underwent intravenous sedation.

This previous findings confirm that patients who experienced intubation for more than 1 week, hospital stay for more than 1 week, prolonged sedation, mechanical complications (laryngeal edema and subglottic edema), VAP, electrolyte imbalance or cardiopulmonary arrest are in high risk of extubation failure.

CONCLUSION

Extubation failure is linked to prolonged intubation, hospital stay, VAP, mechanical complications, high oxygenation index, prolonged sedation and electrolyte imbalance.

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