

The Weaning Practices from the Mechanical Ventilation in the Pediatric Intensive Care Unit at Assiut University Children Hospital

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Abstract

Background: Mechanical ventilation for children and neonates is different from that for adults. While basic principles of physics and gas flow apply to all age groups, anatomical and physiological differences play a significant role in selecting the type of ventilator as well as the ventilatory modes and settings.

Upper airway in children is cephalad funnel-shaped with narrowest area being subglottic (at the level of cricoid ring), as compared to adults where the upper airway is tubular with narrowest part at the vocal cords. Airway resistance increases inversely by 4th power of radius, i.e. in an already small airway, even one mm of edema or secretions will increase the airway resistance and turbulent flow markedly, necessitating treatment of airway edema, suctioning of secretions, measures to control secretions. Low functional residual capacity (FRC: volume of air in the lungs at end of expiration) reduces the oxygen reserve and reduces the time that apnea can be allowed in a child.

Material and Methods: Medical records of children whom were connected to mechanical ventilation in the Pediatric ICU, Assiut University Children Hospital during the period from June 1, 2015 to May 30, 2016 were collected and reviewed to choose the cases which fulfilled the inclusion criteria of the study.

Results: During the period from 1st of June, 2015 to the 30th of May, 2016, 325 patients were admitted to the pediatric ICU, 116 (35.7%) of them were critically ill intubated patients receiving mechanical ventilation and subjected to weaning process.

Conclusions: Nearly, half of the studied cases (49.1%) were successfully weaned, while weaning failure occurred in 31.1% out of the studied cases. Rest of the cases (19.8%) showed extubation failure.

Key Words: Mechanical ventilation – Weaning from mechanical ventilation.

Introduction

WEANING from mechanical ventilation is an essential and universal element in the care of critically ill intubated patients receiving mechanical ventilation. Weaning covers the entire process of liberating the patient from mechanical support and from the endotracheal tube, including relevant aspects of terminal care. There is uncertainty about the best methods for conducting this process, which will generally require the cooperation of the children during the phase of recovery from critical illness. This makes weaning an important clinical issue for patients and clinicians. Immediate, uncomplicated post-operative extubation is excluded from the scope of the current statement [1].

Epidemiology of weaning problems :

Weaning process:

A series of stages in the process of care, from intubation and initiation of mechanical ventilation through initiation of the weaning effort to the ultimate liberation from mechanical ventilation and successful extubation. These six stages are defined as follows:

- 1- Treatment of acute respiratory failure (ARF).
- 2- Suspicion that weaning may be possible.
- 3- Assessment of readiness to wean.
- 4- Spontaneous breathing trial (SBT).
- 5- Extubation; and possibly.
- 6- Reintubation [2].

The usual process of initial weaning from the ventilator:

- *Assessing readiness to wean:*

Prolonged mechanical ventilation is associated with significant morbidity and mortality. Therefore,

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weaning should be considered as early as possible in the course of mechanical ventilation. The process of initial weaning from the ventilator involves a two-step strategy. It begins with an assessment regarding readiness for weaning, which is then followed by SBT as a diagnostic test to determine the likelihood of successful extubation. In fact, for the majority of patients, the entire weaning process simply involves confirmation that the patient is ready for extubation. Patients who meet the criteria reported in table 1 and 2 should be considered as being ready to wean from mechanical ventilation [1].

• *The spontaneous breathing trial:*

Multiple studies have examined the methodology for performing an SBT. There appears to be no difference in either the percentage of patients who pass the SBT or the percentage of patients successfully extubated when a T-tube trial is compared with the use of low levels of pressure support (PS), such as 10cmH₂O in pediatric patients [3], or the use of CPAP [4]. The use of automatic tube compensation (ATC), which adjusts for the assumed resistance of the endotracheal tube, is at least as successful as the use of simple T-tube or low-level PS [5]. Criteria for passing SBT include respiratory pattern, adequate gas exchange, hemodynamic stability and subject comfort. Six large studies [6] demonstrated that only 13% of patients who successfully passed the SBT and were extubated required reintubation. In patients who do not receive an SBT and are extubated, the failure rate is, 40% [7].

Material and Methods

Medical records of children whom were connected to mechanical ventilation in the Pediatric ICU, Assiut University Children Hospital during the period from June 1, 2015 to May 30, 2016 were collected and reviewed to choose the cases which fulfilled the inclusion criteria of the study.

Type of the study: Descriptive study.

Study setting: Pediatric ICU, Assiut University Children Hospital.

Inclusion criteria: Patients aged from 1 month to 18 years, admitted to the ICU, Assiut University Children Hospital during the period from the 1st of June, 2015 to the 30th of May, 2016, and subjected to mechanical ventilation and proceed through the weaning process.

Exclusion criteria:

- Mechanically ventilated patients whom did not proceed through the weaning process.
- Patient with unexpected extubation.

The study methods:

A structured data collection form was designed to collect the clinical and laboratorial data which related to the weaning process from the medical records of the patients whom were included in the study.

The collected data was tabulated, statistically analyzed and discussed.

Results

Data showed that weaning success group was represented by 49.1% out of the 116 studied cases, weaning failure group was represented by 31.1% and extubation failure group was represented by 19.8%.

The main signs reflecting readiness to wean for weaning success group were adequate cough and resolution of disease acute phase for which the patient was intubated, but for weaning failure and extubation failure groups were resolution of disease acute phase for which the patient was intubated and adequate cough.

The present data showed that cases with weaning failure had the lowest rates as regards the clinical manifestations reflecting readiness to wean among the studied group.

As regards the rates of fulfillment of the objective measurements reflecting readiness to wean in relation to the weaning outcome, the present data showed that fulfillment of these measurements ranged from 89.5% to 100% among cases with successful weaning.

Also, the data showed that fulfillment of these measurements among cases with weaning failure ranged from 30.6% to 52.8%.

In addition, the data showed that fulfillment of these measurements among cases with extubation failure ranged from 86.9% to 100%.

Conclusively, cases with weaning failure showed the lowest rates regarding the fulfillment of the objective measurements reflecting readiness to wean among the studied groups.

Regarding the rates of fulfillment of the criteria needed for SBT in relation to the weaning outcome,

most of cases with successful weaning had fulfilled these criteria as follows: Normal respiratory pattern, Adequate gas exchange, Hemodynamic stability and Subject comfort were found in 96.5%, 100%, 98.2% and 96.5% respectively of such cases. While, with weaning failure, only 36.1%, 30.6%, 44.4% and 33.3% respectively were fulfilled these criteria. As regards cases with extubation failure 91.3%, 95.7%, 91.3% and 86.9% were fulfilled the above mentioned criteria.

It is noteworthy that, cases with weaning failure showed the lowest rate of fulfillment of the needed criteria for SBT among the studied groups.

As regards rates of SBT failure criteria among the studied cases in relation to the weaning outcome, data of the present study showed that among cases with successful weaning, the presence of the subjective indices ranged from 10.5% to 19.3%. Depressed mental status showed the highest rate (19.3%), followed by agitation, anxiety and diaphoresis (15.8% for each).

About rates of SBT failure criteria among cases with weaning failure, the subjective indices ranged from 77.8% to 86.1%. Evidence of increasing effort and depressed mental status showed the highest rate (86.1% for each), followed by cyanosis (83.3%).

In cases with extubation failure, rates of the subjective indices ranged from 13% to 21.7%. Evidence of increasing effort and cyanosis showed highest rate (21.7% for each), followed by agitation, anxiety and diaphoresis (17.4% for each).

It is note worthy that, cases with weaning failure showed the highest rates of SBT failure criteria- either subjective or objective-among the three studied groups.

Among the studied cases, 23 cases showed extubation failure, 18 cases (78.3%) out of these 23 cases showed FR >25 breaths/min for 2h as a criteria for extubation failure, 73.9% showed FC >140 beats/min or sustained increase or decrease of >20%, 86.9% showed SaO₂ <90%; PaO₂ <80mmHg on FIO₂ <_0.50, 86.9% showed hypercapnia (PaCO₂ >45mmHg or >_20% from pre-extubation) and 91.3% showed pH <7.33.

It is noteworthy that, pH <7.33 showed the highest rate between the extubation failure criteria among the 23 cases with extubation failure.

Rates of simple weaning, difficult weaning and prolonged weaning were, 75.4%, 14.1% and 10.5% respectively with successful weaning. With weaning failure, they were 0.0%, 66.7% and 33.3% respectively while with extubation failure they were 0.0%, 60.9% and 39.1% respectively.

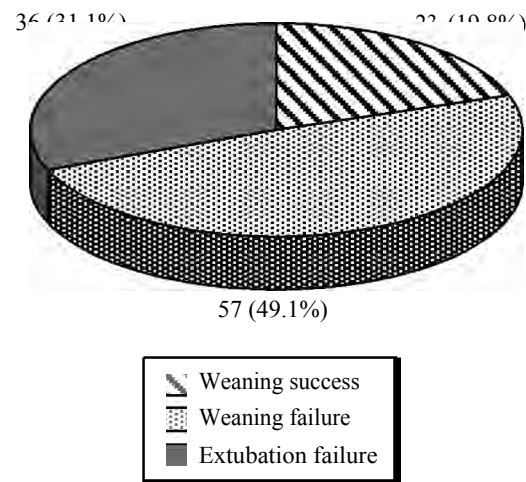


Fig. (1): Weaning outcome among the 116 studied cases.

Table (1): Rates of clinical manifestations reflecting readiness to wean among the 116 studied cases, in relation to the weaning outcome.

Clinical assessment	Weaning success (n.=57)		Weaning failure (n.=36)		Extubation failure (n.=23)	
	Frequency	Rate (%)	Frequency	Rate (%)	Frequency	Rate (%)
Adequate cough	56	98.2	13	36.1	19	82.6
Absence of excessive tracheobronchial secretion	50	87.8	12	33.3	18	78.3
Resolution of disease acute phase for which the patient was intubated	51	89.5	15	41.7	21	91.3

Table (2): Rates of fulfillment of the objective measurements reflecting readiness to wean among the studied cases in relation to the weaning outcome.

Objective measurements	Weaning success (n.=57)		Weaning failure (n.=36)		Extubation failure (n.=23)	
	Frequency	Rate (%)	Frequency	Rate (%)	Frequency	Rate (%)
<i>Clinical stability:</i>						
- Stable cardiovascular status:	51	89.5	17	47.2	22	95.7
• IO \leq 140 beats/min	53	92.9	15	41.7	21	91.3
• Systolic BP 90-160 mmHg	53	92.9	16	44.4	20	86.9
• Stoppage of vasopressors	56	98.2	13	36.1	21	91.3
- Stable metabolic status						
<i>Adequate oxygenation</i>						
-SaO ₂ >90% on \leq FiO ₂ 0.4 (or PaO ₂ /FiO ₂ \geq 150mmHg)	57	100	11	30.6	23	100
-PEEP \leq 8 cmH ₂ O	57	100	14	38.9	22	95.7
<i>Adequate pulmonary function</i>						
- fR \leq 35 breaths/min	52	91.2	16	44.4	21	91.3
- MIP \leq 20-25 cmH ₂ O	54	94.7	12	33.3	22	95.7
- VT >5 mL/k	56	98.2	17	47.2	23	100
- VC >10 mL/kg	55	96.5	17	47.2	22	95.7
- No significant respiratory acidosis	57	100	19	52.8	23	100
- FR/VT <105 breaths/min	56	98.2	16	44.4	21	91.3
<i>Adequate mentation</i>						
- No sedation or adequate mentation on sedation (or stable neurologic patient)	57	100	20	55.6	21	91.3

Table (3): Rates of fulfillment of the needed criteria for SBT in relation to the weaning outcome.

Needed criteria for SBT	Weaning success (n.=57)		Weaning failure (n.=36)		Extubation failure (n.=23)	
	Frequency	Rate (%)	Frequency	Rate (%)	Frequency	Rate (%)
Normal respiratory pattern	55	96.5	13	36.1	21	91.3
Adequate gas exchange	57	100	11	30.6	22	95.7
Hemodynamic stability	56	98.2	16	44.4	21	91.3
Subject comfort	55	96.5	12	33.3	20	86.9

Table (4): The criteria of SBT failure among the studied cases in relation to weaning outcome

Failure criteria of SBT	Weaning success (n.=57)		Weaning failure (n.=36)		Extubation failure (n.=23)	
	Frequency	Rate (%)	Frequency	Rate (%)	Frequency	Rate (%)
<i>Clinical assessment and subjective indices:</i>						
- Agitation anxiety	9	15.8	29	80.6	4	17.4
- Depressed mental status	11	19.3	31	86.1	3	13.0
- Diaphoresis	9	15.8	28	77.8	4	17.4
- Cyanosis	7	12.3	30	83.3	5	21.7
- Evidence of increasing effort	6	10.5	31	86.1	5	21.7
<i>Objective measurements:</i>						
- PaO ₂ \leq 50-60 mmHg on FIO ₂ \geq 0.5 or SaO ₂ <90%	0	0.0	28	77.8	0	0.0
- PaCO ₂ >50 mmHg or an increase in PaCO ₂ >8 mmHg	0	0.0	29	80.6	0	0.0
- pH <7.32 or a decrease in pH \geq 0.07 pH units	0	0.0	28	77.8	0	0.0
- fR/VT >105 breaths/min	1	1.8	25	69.4	2	8.7
- fR >35 breaths/min or increased by \geq 50%	5	8.8	26	72.2	2	8.7
- IO >140 beats/min or increased by \geq 20%	6	10.5	25	69.4	1	4.3
- Systolic BP >180 mmHg or increased by \geq 20%	0	0.0	8	22.2	0	0.0
- Systolic BP <90 mmHg	4	7.0	23	63.9	2	8.7
- Cardiac arrhythmias	0	0.0	8	22.2	0	0.0

Table (5): Extubation failure criteria among the 23 studied cases.

Extubation failure criteria	Frequency	Rate (%)
FR >25 breaths/min for 2h	18	78.3
FC >140 beats/min or sustained increase or decrease of >20%	17	73.9
<i>Clinical signs of respiratory muscle fatigue or increased work of breathing :</i>		
SaO ₂ <90%; PaO ₂ <80mmHg on FIO ₂ ≤0.50	20	86.9
Hypercapnia (PaCO ₂ >45mmHg or ≥20% from pre-extubation)	20	86.9
pH <7.33	21	91.3

Table (6): Weaning classification in relation to the weaning outcome among the studied cases.

Weaning classification	Weaning success (n.=57)		Weaning failure (n.=36)		Extubation failure (n.=23)	
	Frequency	Rate (%)	Frequency	Rate (%)	Frequency	Rate (%)
Simple weaning	43	75.4	0	0.0	0	0.0
Difficult weaning	8	14.1	24	66.7	14	60.9
Prolonged weaning	6	10.5	12	33.3	9	39.1

Discussion

The present results showed that the main signs reflecting readiness to wean for weaning success group were adequate cough and resolution of disease acute phase for which the patient was intubated, but for weaning failure and extubation failure groups were resolution of disease acute phase for which the patient was intubated and adequate cough.

Prolonged mechanical ventilation is associated with significant morbidity and mortality. Therefore, weaning should be considered as early as possible in the course of mechanical ventilation. The process of initial weaning from the ventilator involves a two-step strategy. It begins with an assessment regarding readiness for weaning, which is then followed by SBT as a diagnostic test to determine the likelihood of successful extubation. In fact, for the majority of patients, the entire weaning process simply involves confirmation that the patient is ready for extubation. Patients who meet the criteria should be considered as being ready to wean from mechanical ventilation [1].

Data of the present study showed that adequate oxygenation (SaO₂ >90% on ≤FiO₂ 0.4 (or PaO₂/FiO₂ ≥ 150mmHg) and PEEP ≤8cmH₂O), adequate mentation and no significant respiratory acidosis had the highest rate of objective measurements reflecting readiness to wean among weaning success group, followed by VT >5mL/k and FR/VT <105 breaths/min.

For many patients, discontinuation of sedation is a critical step that can be achieved by either daily interruption of sedation or continuous titration of sedation to a level that allows the patient to be adequately responsive [4].

Results of the present study showed that adequate mentation had the highest rate of objective measurements reflecting readiness to wean among weaning failure group, followed by no significant respiratory acidosis ,fC ≤ 140beats/min, VT >5mL/k and VC >10mL/kg.

The present data showed that adequate oxygenation (SaO₂ >90% on ≤FiO₂ 0.4 (or PaO₂/FiO₂ ≥ 150 mmHg), no significant respiratory acidosis and VT >5mL/k had the highest rate of objective measurements reflecting readiness to wean among extubation failure group, followed by adequate oxygenation (PEEP ≤8cmH₂O), fC ≤ 140 beats/min, VC >10mL/kg and MIP ≤20-25cmH₂O.

The present results showed that adequate gas exchange had the highest rate among weaning success and extubation failure group as a fulfillment of criteria needed for SBT, hemodynamic stability had the highest rate among weaning failure group.

Data of the present study showed that depressed mental status had the highest rate, followed by agitation, anxiety and diaphoresis as regards the criteria of SBT failure by clinical assessment and subjective indices among weaning success group and by objective measurements, fC >140 beats/min

or increased by ≥ 20 had the highest rate, followed by $fR > 35$ breaths/min or increased by $\geq 50\%$.

When patients fail an initial SBT, the clinician should review possible reversible etiologies for failure. The SBT should be repeated frequently (daily) in order to determine the earliest time at which the patient can be successfully extubated although respiratory muscle fatigue has been considered to be a major reason for continuing failure to wean from mechanical ventilation [8]. Patients who fail the initial SBT should receive a non-fatiguing mode of mechanical ventilation (generally either assist-control or PSV) [9].

Results of the present study showed that evidence of increasing effort and depressed mental status had the highest rate as regards the criteria of SBT failure by clinical assessment and subjective indices among weaning failure group, followed by cyanosis and by objective measurements, $PaCO_2 > 50$ mmHg or an increase in $PaCO_2 > 8$ mmHg had the highest rate followed by $PaO_2 < 50-60$ mmHg on $FIO_2 \geq 0.5$ or $SaO_2 < 90\%$ and $pH < 7.32$ or a decrease in $pH \geq 0.07$ pH units.

Data of the present study showed that evidence of increasing effort and cyanosis had highest rate as regards the criteria of SBT failure by clinical assessment and subjective indices among extubation failure group, followed by agitation, anxiety and diaphoresis and by objective measurements, $fR/VT > 105$ breaths/min, $fR > 35$ breaths/min or increased by $\geq 50\%$ and systolic BP < 90 mmHg had the highest rate, followed by $fC > 140$ beats/min or increased by $\geq 20\%$ (4.3%).

The present data showed that the main criteria of extubation failure were clinical signs of respiratory muscle fatigue or increased work of breathing ($pH < 7.33$, $SaO_2 < 90\%$; $PaO_2 < 80$ mmHg on $FIO_2 < 0.50$, hypercapnia ($PaCO_2 > 45$ mmHg or $\geq 20\%$ from pre-extubation).

Conclusions:

Respiratory failure was the commonest indication for mechanical ventilation among the studied cases.

Nearly, half of the studied cases (49.1%) were successfully weaned, while weaning failure occurred in 31.1% out of the studied cases. Rest of the cases (19.8%) showed extubation failure.

As regards the pathophysiologies which impact on the ability to wean, respiratory load was the

commonest pathophysiology among the three studied groups, reduced compliance due to pneumonia was the main cause among cases with successful weaning. Cardiac load caused by unresolved sepsis and neuromuscular affection caused by sedative/hypnotic medications, as well as respiratory load caused by inappropriate ventilation settings were common pathophysiologies among both weaning failure and extubation failure groups.

Weaning outcome depends mainly on fulfillment of both subjective and objective criteria reflecting readiness to wean, as well as fulfillment of the needed criteria for SBT.

Successful weaning was mostly of the simple weaning type, while weaning was either difficult or prolonged for all cases of failure, i.e. weaning failure or extubation failure.

None of the cases with prolonged weaning failure were subjected to tracheostomy or rehabilitation.

Recommendations:

- Reversible pathology should be aggressively and repeatedly sought in all patients.
- Ongoing surveillance for respiratory load, cardiac load, neuromuscular competence, ventilation settings as well as use of sedative/hypnotic medications is recommended.
- Criteria reflecting readiness to wean or needed for SBT should be fulfilled before weaning, clinicians should evaluate readiness for weaning early in the hospital course to allow prompt initiation of the weaning process.

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ممارسات الفطام من التهوية الميكانيكية فى وحدة العناية المركزة للأطفال بمستشفى اسيوط الجامعى

المقدمة: التهوية الميكانيكية فى الاطفال وحديثى الولادة تختلف عنه فى الكبار كما ان اختيار جهاز التنفس الصناعى يختلف ايضا حسب الفروق التشريحية والفسيوولوجية بين الاعمار المختلفة، حيث ان الممر الهوائى فى الاطفال قمعى الشكل واضيق جزء فيه يكون تحت المزمار، إما الممر الهوائى فى الكبار فهو انبوى الشكل واضيق جزء فيه يوجد عند الاحبال الصوتية.

الهدف من العمل: تقييم ممارسات الفطام من اجهزة التهوية الميكانيكية فى وحدة العناية المركزة للأطفال بمستشفى جا معة اسيوط والبحث عن نقاط القوة لدعمها، وكذلك نقاط الضعف مثل المعوقات و مواطن الخلل والاحتياجات لرفع مستوى الخدمة الصحية التى تقدمها هذه الوحدة. ونحن نعتبر ان هذا التقييم النقدى لأدائنا خطوة حاسمة قبل اجراء اى اصلاحات او تطوير لهذا الاداء.

طرق البحث: تم تجميع البيانات العملية والمعملية فيما يخص عملية الفطام من الملفات الخاصة بالمرضى الذين تم اختيارهم للرسالة.

النتائج: اثبتت الدراسة ان ٤٩.١٪ من الحالات تمت معهم عملية الفطام بنجاح وتم فصلهم من اجهزة التهوية الميكانيكية بينما ١٣.١٪ انتهت معهم عملية الفطام بالفشل ولم يتم فصلهم من اجهزة التهوية الميكانيكية و ١٩.٨٪ تعرضوا لفشل نزع الانبوب الحنجرى منهم وتم اعادة توصيلهم مرة اخرى.