

**The use of Extubation Readiness Parameters: A Survey of Pediatric Critical Care
Physicians**

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Running Head: The use of Extubation Readiness Parameters

Abstract:

Background: The pediatric literature addressing extubation readiness parameters and strategies to wean from mechanical ventilation is limited in children.

Methods: A survey was designed to assess the implementation of extubation readiness parameters among Pediatric Critical Care Physicians who are affiliated to academic centers in the United States.

Results: The overall response rate to the survey was 44.1% (417/945). The majority of responders check for an air leak, and check for the amount of tracheal secretions; and fewer physicians use sedation scores, perform a Rapid Shallow Breath Index (RSBI), and measure an airway occlusion pressure at 0.1 sec ($P_{0.1}$ sec) prior to extubation. The majority perform a SBT with pressure support (PS). The majority consider 30 cm of H₂O as the upper limit of an air leak test, and the need for endotracheal suctioning once every 2-4 hours as acceptable for extubation. In preparation for termination of mechanical ventilation the majority wean daily ventilator rates and or PS instead of daily SBT.

Conclusions: Most PCCP report assessing extubation readiness by checking for air leak and suctioning needs, and less often consider or perform sedation scores or RSBI. Future studies on the best extubation parameters in children are needed.

Introduction:

The number of mechanically ventilated children is increasing along with an increase in health care cost in the United States. Over the last decade, the estimated number of children requiring intubation and mechanical ventilation has increased by 11%; however this increase in health care demand was associated with a disproportional increase in health care cost by 97%.^{1,2} Therefore interventions aimed to improve care at lower cost are needed. For instance timely extubation, as determined by extubation readiness parameters, may prevent ventilator associated complications, decrease days of mechanical ventilation, and improve care and lower cost.

While invasive mechanical ventilation is often life saving, it can be associated with complications such as ventilator-induced lung injury, ventilator associated pneumonia and endotracheal tube-associated airway injuries.³ Therefore it is important that mechanical ventilation be discontinued as soon as patients are capable of sustaining spontaneous breathing on their own. However discontinuation of mechanical ventilation prematurely can be detrimental, and can be associated with a significant morbidity and mortality in adults and children.^{4,5,6,7,8} In children, half of the unplanned or accidental self extubations are successful implying that many pediatric patients are ventilated for an excessive period of time.⁹ On the other hand, the rate of failed planned extubation rate in pediatric patients is elevated, ranging between 2% and 20%.³ Using parameters to predict readiness for extubation in children is one of many factors that would improve the quality of care of critically ill children and decrease morbidity and complications related to mechanical ventilation. Studies in adults^{10,11} and pediatric patients^{12,13} have shown that when patients pass a spontaneous breathing trial (SBT) and are subjected to an extubation

readiness trial (ERT), 50% to 75% of these patients are considered ready for extubation.

In this survey we sought to determine the frequency of use of extubation readiness parameters such as the air leak, RSBI, $P_{0.1}$ sec, quantification of secretions and sedation,³ the methods used, and the attitude toward performing these parameters among Pediatric Critical Care Physicians (PCCP).

Materials and Methods:

The studied Population & Administration of the survey:

The studied population consisted of all PCCP who work in hospitals with a pediatric residency program in the U.S. Hospitals with pediatric residency programs were identified from the Fellowship and Residency Electronic Interactive Database (FREIDA) website at <https://freida.ama-assn.org> which is an online database of accredited graduate medical education programs and specialty programs in the US. The database is maintained by the American Medical Association (AMA). The names and e-mails of the PCCP were then retrieved from the above mentioned identified hospital websites where available.

The electronic mail survey was conducted using SurveyMonkey that is available at www.surveymonkey.com. The emails had a unique link to the survey. For people who did not respond in two weeks, two further e-mails were sent, two weeks apart, as reminders. The survey was initially submitted on March 3rd, 2011 and it was followed by two reminders that were two weeks apart. The survey was closed on April 24th, 2011.

Consent was sought in the first e-mail, and the reply to the survey implied the agreement of the respondents. The survey was approved by the Institution Review Board (IRB) at Metro Health Medical Center.

Development & Administration of the survey:

A survey was designed to assess the familiarity, attitude, and frequency of implementation of extubation readiness parameters among PCCP.¹⁴ Physicians' demographics and characteristics of their intensive care units, and the best guess for the percentage of extubation failure in their unit were collected. Extubation failure was

defined as the need for re-intubation within 48 hours following extubation. Physicians were surveyed about five extubation readiness parameters including measurement of the “Air Leak” test around the endotracheal tube, measurement of the amount of tracheal secretions, performance of a Rapid Shallow Breath Index (RSBI), measurement of the airway occlusion pressure at 0.1 sec ($P_{0.1}$ sec) and use of a sedation score to assess patient’s readiness for extubation. Physicians were also surveyed about the use of Spontaneous Breathing Trials (SBT) and strategies to wean from mechanical ventilation.

The survey consisted of 19 questions (Appendix). Familiarity with the extubation readiness parameters and methods used to perform these parameters were assessed.

The attitude toward performance of different extubation parameters were assessed with a 5-point Likert scale questions (ranging from strongly disagree to strongly agree).

The PCCP decisions and frequency of implementation of extubation readiness parameters were assessed with a 7-point Likert scale questions (ranging from never to always), and daily wean versus daily performance of SBT in preparation for extubation.

Statistical Analysis:

The data were expressed as mean \pm standard deviation. To determine if there was a statistically significant difference in physicians’ response to agree to conduct or perform the five extubation readiness tests, a Friedman’s Two-Way Analysis of Variance by Ranks (non parametric) was used grouping all physicians. Such analysis was important to grade the strength of agreement to conduct or perform each individual test in comparison to the other tests; in order to develop a potential scoring system for extubation readiness in the future. For instance tests with high values will weigh

differently on the scoring system than tests with low values.” A chi square test was used to compare categorical data. A p value < 0.05 was considered statistically significant.

The statistical software IBM SPSS Statistics version 19 (SPSS, Chicago, IL) was used for the statistical analysis of the data. To assess the consistency among individual institutions with multiple (≥ 5) respondents, a coefficient of variation was calculated for each question addressed to the same group of physicians belonging to the same institution.

Results:

A total of 1,089 physicians were identified, 113 physicians did not have their email addresses available on line. A total of 976 physicians with available e-mails were identified through their hospitals web sites. Among all physicians 16 opted out of the survey, and 15 others' e-mails bounced back. Overall the response rate to the survey was 44.1% (417/945); and 78% (120/154) of all institutions had at least one responder.

The physicians' demographics and their pediatric intensive care units' characteristics are summarized in Table 1.

Assessment of physicians' familiarity with different extubation readiness tests and methods used to test extubation readiness:

The majority of physicians, 86% (352/407), check for an air leak prior to extubation; 38.5% (157/409) reported 20 cm of H₂O as the acceptable upper limit and 44.5% (182/409) reported 30 cm of H₂O as the acceptable upper limit for an air leak test. Overall 83% (339/409) consider up to 30 cm of H₂O as the upper limit for an air leak prior to extubation.

47% (193/410) of the responders considered suctioning once every 2 hours as acceptable, 22.4 % (92/410) considered once every 3 to 4 hours as acceptable and 20% (82/410) considered once every hour as acceptable. Overall 69.5% (285/410) consider suctioning once every 2-4 hours as acceptable, and 89.5% (367/410) check for endotracheal secretions prior to extubation.

The majority of the responders, 97% (401/415), do not perform the P_{0.1} sec test; and among responders or 3% (14/415) who measure P_{0.1} sec, 43% (6/14) consider a P_{0.1}

sec of ≤ 4 cm of H₂O as acceptable for extubation and the majority consider ≤ 5 cm as acceptable.

The majority of physicians, 94.5% (381/403), report performing a SBT mainly using continuous Positive Airway Pressure (CPAP) and Pressure Support (PS) (Figure 1). The majority of the responders, 83 % (344/414), do not perform a RSBI prior to extubation; and among the 17% (70/414) of physicians who perform a RSBI, 51% (36/70) perform the test with a PS that is adapted to the size of the endotracheal tube, 54 % (31/57) consider the upper limit of ≤ 10 breaths/min/ml/kg as acceptable for extubation and the majority consider ≤ 12 breaths/min/ml/kg as acceptable.

The majority, 62% (257/416) assess their patients clinically without using a formal sedation score. Overall 38% (159/416) use a sedation score. Twenty percent (85/416) use a Glasgow Coma Score (GCS), 18.8% (78/ 416) use a COMFORT scale, and 18.5% (77/416) use other scales.

Assessment of physicians' attitude toward performing extubation readiness tests:

Quantification of secretions and checking for an air leak test had the highest agreement scores among physicians (Figure 2). There was a statistically significant difference in physicians' overall response to the five different tests ($p < 0.001$).

Assessment of physicians' decision and frequency of performance of different tests:

Twenty-one percent (84/408) of the responders always perform a SBT test versus 9% (37/408) of the responders who would never perform the test ($p < 0.0001$). In preparation for termination of mechanical ventilation, 76 % (309/408) wean daily the ventilator rate and or PS and extubate when patient is ready, 6% (24/408) perform daily SBT and extubate when patient is ready and 18% (75/408) perform both.

Most physicians would check for the amount of tracheal secretions followed by measuring the air leak test, and use of a sedation score (Figure 3). There was a statistically significant difference in physicians' response to the five different tests ($p < 0.001$). Overall 36% (150/415) of all respondents always check for an air leak test, 62% (259/415) always check for the amount of tracheal secretions, 0.5% (2/415) always measure the P0.1 sec, 2.4% (10/415) always perform a RSBI, and 23% (96/415) always use a sedation score prior to extubation.

To determine if years of practice had an effect on the different techniques used by physicians, the data was analyzed by years of practice. There were no differences between physicians with different years of practice and percentage of assessment of the air leak, amount of ETT secretions, P0.1 sec, RSBI, and sedation score. However; 12% (12/99) of the responders with less than 5 years of practice perform the SBT with CPAP versus 22% (70/317) of the responders with 5 years of practice or more ($p = 0.029$)

To determine if there is variability in practice among physicians belonging to the same institution, a coefficient of variation was calculated for each question addressing the assessment (on a Likert scale from 1 to 7) of the five extubation readiness tests. There was a significant difference in response to the same question among physicians belonging to same institution (coefficient of variation ranging from 0% to 100%).

Discussion

This survey has shown that most physicians perform a SBT, check for an air leak test around the endo-tracheal tube and measure the amount of tracheal secretions prior to extubation. In preparation for termination of mechanical ventilation the majority performs a daily weaning of the ventilator rate and or PS and fewer performs a daily SBT to assess patients for extubation. The pediatric literature addressing extubation readiness parameters and strategies to wean off mechanical ventilation is limited in children;³ in contrast to an extensive adult evidence based literature.¹⁵

In adults spontaneous breathing trials are commonly used to determine readiness for extubation.¹⁶ In children spontaneous breathing trials have been shown to be feasible, to have a high sensitivity for predicting extubation success and to decrease days of mechanical ventilation.^{5,17,18} The results of the current survey reflect in a way the available pediatric literature and suggest a need for further investigations to determine the barriers that prevent physicians from adopting daily SBT strategies over traditional daily weaning strategies, and support the need for future randomized controlled studies to validate the utility of such tests.

The use of PS adjusted for endo-tracheal tube size has been advocated to overcome endo-tracheal tube resistance during an extubation readiness trial.¹² However performance of a SBT using a PS set at higher levels for smaller endo-tracheal tubes has been shown to overestimate readiness for extubation in children.¹⁹ The response to our survey reflects the uncertainty regarding the performance of such test. In adults an elevated RSBI predicts failure^{15, 16} whereas in children the performance and outcomes of

such test have been debated and questioned.^{3,13,20} The results of the survey reflect the limited and conflicting pediatric literature on RSBI in children.

Upper airway obstruction is one of the major causes of extubation failure in children.⁸ An air leak test, that measures air leak around the endo-tracheal tube is usually used to predict upper airway obstruction following extubation. In adults, several studies have shown that an air leak test can be predictable of post extubation stridor.^{21,22,23} In children, it has been previously shown that an air leak test can be predictable of post extubation stridor without predicting extubation failure or success.²⁴ A previous survey has shown that the majority of physicians would delay extubation and recommend usage of steroids if there was no evidence of an air leak at 30 cm of H₂O.²⁵ However, when studied, an air leak pressure equal or superior to 30 cm of H₂O did not predict extubation failure or outcome.²⁶ The current survey reflects the concern of most physicians regarding post extubation stridor despite the lack of evidence that an air leak does not predict success or failure of extubation.

In children, the amounts of secretions that are predictable of extubation success or failure have not been studied. In adults, although moderate to copious tracheal secretions are predictable of extubation failure,^{27,28} only few physicians rely on the amount of tracheal secretions as an extubation readiness parameter.²⁹ Quantification of tracheal secretions is difficult. The amounts of secretions can be assessed clinically accordingly to a semi quantitative scale based on the frequency of requirement to suction, once every 2 to 4 hours, once every 1 to 2 hours, or several times per hour;²⁷ or electronically an acoustic secretion detector device to depict the need for endotracheal suctioning before patients manifest signs of respiratory distress.³⁰ The current survey reflects the

importance of tracheal secretions in the decision making of physicians, caring for critically ill children.

Excessive or inefficient sedation can both be detrimental in mechanically ventilated children. The use of continuous sedation is associated with an increase in the duration of mechanical ventilation,³¹ and daily interruption of sedation is associated with a decrease in the duration of mechanical ventilation in children.³² Altered mental status and absence of airway reflexes at the time of extubation are associated with extubation failure in children,³³ but ineffective sedation, is also associated with unplanned extubation and post extubation stridor.³⁴ The current survey shows that the majority of physicians consider that sedation is an important element for extubation readiness and do not use a formal standardized sedation score, instead they use their own clinical judgment. These findings underline the importance of developing a standardized, easy to use sedation score that can be adopted by most physicians to standardize care.

The $P_{0.1}$ sec, an index of respiratory center output and neuromuscular drive, correlates well with the mechanical output of the inspiratory muscles.^{35,36} In few studies, the $P_{0.1}$ sec was useful in setting the optimal level of PS, and predicting extubation success in adults;^{37,38,39} and in assessing the respiratory drive and muscle function, and predicting extubation failure in children.⁴⁰ However, in other studies, the $P_{0.1}$ sec was a poor predictor of extubation failure in adults.^{41,42} The results of our survey reflect the literature.

The study has limitations. The response rate to the survey was only 44.1% despite attempts to improve the response rate; however our rate was similar to the response rate

seen with other surveys targeting the same population,^{43,44} and the response of the surveyed physicians reflected well the pediatric literature. A potential explanation for the low response rate could be due to the fact that some of the retrieved e-mails from hospitals' websites belonged to non practicing individuals and affected the overall number of responders. Many physicians did not have their e-mails available on line, and therefore could not be surveyed. The survey targeted only practicing physicians in academic centers. The results of the survey could have differed if all academic and non academic physicians were surveyed. However academic physicians were targeted in particular, since their responses most probably reflect the current teaching of fellows and physicians in training who will become the future practitioners. Also it is possible that the physicians who responded to the survey have a special interest in the topic and have biased the results; and as with any survey, clinicians say they do may not be what they really do.

Conclusion

This survey shows that most physicians check for an air leak and tracheal secretions prior to extubation. In preparation for termination of mechanical ventilation the majority weans daily the ventilator rate and or PS and fewer performs daily SBT to assess patients for extubation. Future studies are needed to determine the best extubation readiness tests in order to develop consensus guidelines.

Figures Legend:

Figure 1: The percentage of physicians performing a Spontaneous Breathing Trial (SBT) using Continuous Positive Airway Pressure (CPAP) with and without Pressure Support (PS), Tracheal (T) piece and who do not perform such trial.

Figure 2: Agreement to perform an extubation readiness test on a 5-point Likert scale among Pediatric Critical Care Physicians. There is a statistically significant difference in their response ($p < 0.001$; Friedman's Two-Way Analysis of Variance by Ranks)

Figure 3: Frequency of Performance of Different Extubation Readiness Tests on a 7-point Likert Scale among Pediatric Critical Care Physicians. There is a statistically significant difference in their response ($p < 0.001$; Friedman's Two-Way Analysis of Variance by Ranks)

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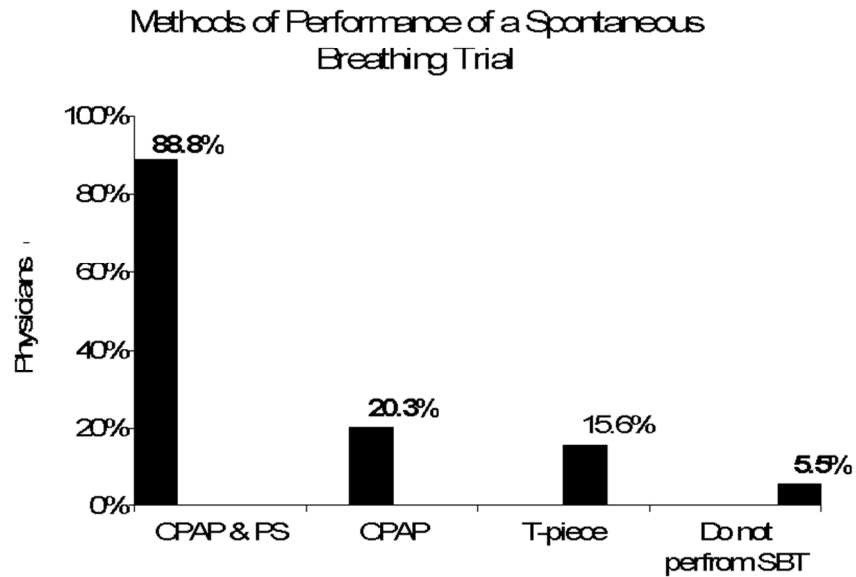
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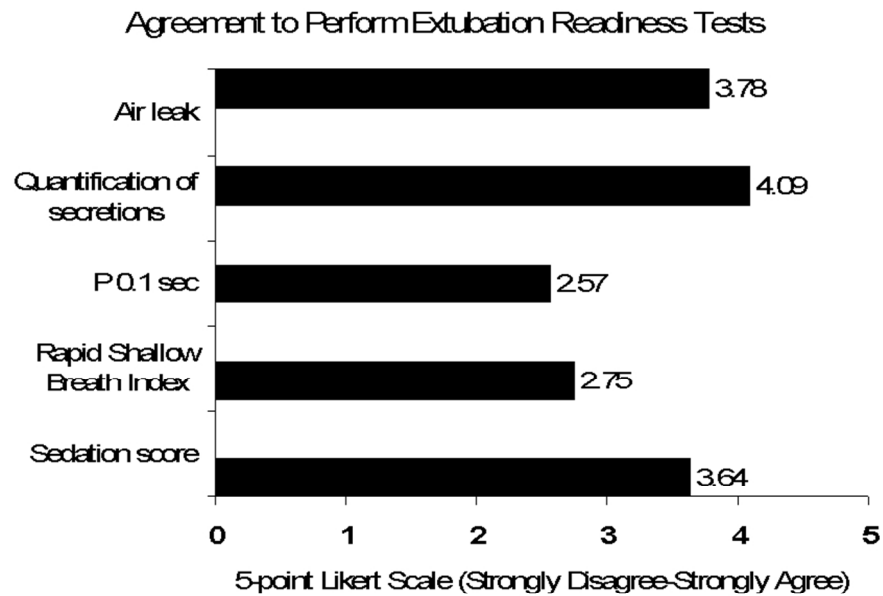
Table 1: Physicians' Demographics & Pediatric Intensive Care Units' Characteristics

Age:	30-40 years	157/416 (37.7%)
	41-50 years	163/416 (39.2%)
	51-60 years	81/416 (19.5%)
	> 60 years	15/416 (3.6%)
Gender:	Male	261/414 (63%)
	Female	153/414 (37%)
Years of practice:	<5 years	99/416 (23.8%)
	5-10 years	112/416 (26.9%)
	> 10 years	205/416 (49.3%)
Board Certification:	Yes	381/414 (92%)
	No	33/414 (8%)
Number of beds	< 10 beds	18/416 (4.3%)
	10-15 beds	76/416 (18.3%)
	16-20 beds	95/416 (22.8%)
	> 20 beds	227/416 (54.6%)
Presence of fellows	Yes	273/413 (66.1%)
	No	140/413 (33.9%)
% Reported of Extubation Failure:	<5%	185/417 (44.4%)
	5%-10%	186/417 (44.6%)
	11%-15%	31/417 (7.4%)
	16%-20%	6/417 (1.4%)

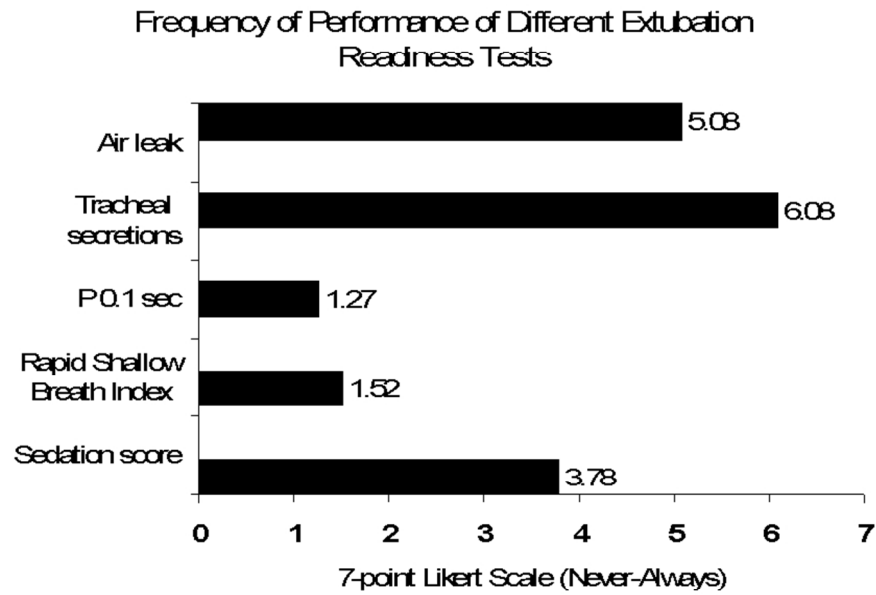


The percentage of physicians performing a Spontaneous Breathing Trial (SBT) using Continuous Positive Airway Pressure (CPAP) with and without Pressure Support (PS), Tracheal (T) piece and who do not perform such trial.

254x190mm (96 x 96 DPI)



Agreement to perform an extubation readiness test on a 5-point Likert scale among Pediatric Critical Care Physicians. There is a statistically significant difference in their response ($p < 0.001$; Friedman's Two-Way Analysis of Variance by Ranks)
254x190mm (96 x 96 DPI)



Frequency of Performance of Different Extubation Readiness Tests on a 7-point Likert Scale among Pediatric Critical Care Physicians. There is a statistically significant difference in their response ($p < 0.001$; Friedman's Two-Way Analysis of Variance by Ranks)
254x190mm (96 x 96 DPI)