ORIGINAL ARTICLE

Risk factors for post-extubation stridor in children: the role of orotracheal cannula

Fatores de risco para estridor pós-extubação em crianças: o papel da cânula orotraqueal

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ABSTRACT

Objective: To determine the risk factors associated with stridor, with special attention to the role of the cuffed orotracheal cannula. **Methods:** Prospective analysis of all the intubated patients submitted to mechanical ventilator support from January 2008 to April 2011. The relevant factors for stridor collected were age, weight, size and type of airway tube, diagnosis, and duration of mechanical ventilation. The effects of variables on stridor were evaluated using uni- and multivariate logistic regression models. **Results:** A total of 136 patients were included. Mean age was 1.4 year (3 days to 17 years). The mean duration of mechanical ventilation was 73.5 hours. Fifty-six patients (41.2%) presented with stridor after extubation. The total reintubation rate was 19.6% and 12.5 in patients with and without stridor, respectively. The duration of mechanical ventilation (>72 hours) was associated with a greater risk for stridor (*odds ratio* of 8.60; 95% confidence interval of 2.98-24.82; p<0.001). The presence of the cuffed orotracheal cannula was not associated with stridor (*odds ratio* of 98; 95% confidence interval of 0.46-2.06; p=0.953). **Conclusion:** The main risk factor for stridor after extubation in our population was duration of mechanical ventilation. The presence of the cuffed orotracheal cannula was not associated with increased risk for stridor, reinforcing the use of the cuffed orotracheal cannula in children with respiratory distress.

Keywords: Respiratory sounds; Risk factors; Intubation, intratracheal/instrumentation; Child

RESUMO

Objetivo: Determinar os fatores de risco associados ao estridor, com especial atenção para o papel da cânula orotraqueal. **Métodos:** Análise prospectiva de todos os pacientes entubados submetidos à ventilação mecânica no período de janeiro de 2008 a abril de 2011. Os fatores relevantes para estridor coletados foram idade, peso, tamanho e tipo da cânula orotraqueal, diagnóstico, e duração da ventilação mecânica. Os efeitos das variáveis sobre estridor foram avaliados utilizando modelos de regressão logística uni e multivariada. **Resultados:** Foram incluídos 136 pacientes. A média de idade foi 1,4 ano (3 dias a 17 anos). O tempo médio de ventilação mecânica foi 73,5 horas. Apresentaram estridor após extubação 56 pacientes (41,2%). A taxa de reintubação foi de 19,6% e 12,5% em pacientes com ou sem estridor, respectivamente. A duração da ventilação mecânica (>72 horas) foi associada a um maior risco de estridor (*odds ratio* de 8,60; intervalo de confiança de 95% de 2,98-24,82; p<0,001). A presença da cânula orotraqueal não foi associada ao estridor (*odds ratio* de 0,98; intervalo de confiança de 95% de 0,46-2,06; p=0,953). **Conclusão:** O principal fator de risco para estridor após extubação em nossa população foi o tempo de ventilação mecânica. A presença da cânula orotraqueal não foi associada a maior risco de estridor, reforçando o uso de cânulas com balonete em crianças com dificuldade respiratória.

Descritores: Sons respiratórios; Fatores de risco; Intubação intratraqueal/instrumentação; Criança

INTRODUCTION

The conventional management of severe respiratory distress in children with respiratory failure consists of mechanical ventilation (MV) in the pediatric intensive care unit (PICU). Endotracheal intubation is frequently used for respiratory support and this procedure may lead to associated side effects and complications. The

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presence of atelectasis and post-extubation stridor accounts for 30% of all complications related to MV in children.[1] The incidence of stridor after extubation in children ranges from 3.5 to 30.2%.[1,2] This wide range of incidence can be explained by the variability and lack of objectivity of the definitions of stridor.[3] The presence of post-extubation stridor in children may prolong length of stay in the PICU, particularly if reintubation is necessary.

Several factors such as age, weight, length of MV, size of orotracheal cannula (OTC), presence of a cuffed tube, and underlying indication for MV that have been associated with post-extubation stridor. Some methods have been used to predict post-extubation stridor, such as the air leak test, but the low sensitivity in young children makes the identification of patients at risk troublesome.[4,5] As a result, pediatric intensivists must be aware of all the main risk factors associated with stridor when attending to an intubated child.

The presence of a cuffed OTC has been traditionally associated with stridor in young children, leading to the classical indication of uncuffed OTC in children under the age of 8 years.[6] However, in recent years, and after the recommendation of cuffed OTC use in certain circumstances (*e.g.*, poor lung compliance, high airway resistance, or a large glottic air leak) by the American Heart Association,[7] there has been an increasing interest in cuffed tubes in pediatric practice, in the operating room or in the PICU.

OBJECTIVE

To identify the predictors of stridor after extubation in children admitted to a pediatric intensive care unit of a private hospital with special attention regarding the relation between cuffed and uncuffed orotracheal cannula.

METHODS

This prospective cohort study was performed in a multidisciplinary, 14-bed PICU of *Hospital Israelita Albert Einstein*, a private organization, from January 2008 to May 2011. The study was approved by the hospital Ethics Committee, under the registration number 10/1450, and the need for informed consent was waived because no intervention was attempted and the confidentiality of the patients' data was preserved.

All patients that met the following inclusion criteria were included: age less than 18 years; and requirement of OTC and MV for more than 24 hours. Patients were excluded for death after MV without extubation attempts; receiving prophylactic corticosteroids; known vocal cord paralysis or malacia; and limitations of medical care in place. Assigned patients were accompanied for 72 hours after extubation. We used the definition of stridor as any noisy breathing, specifically a high-pitched crowing sound associated with airway obstruction after intubation. Although there are some scores in the literature, no standardized score for stridor was used. The daily evaluation was performed by the pediatric intensivist and the respiratory physical therapist. Along with presence of stridor, signs of respiratory distress, (SpO_2) <92%, and level of consciousness were also observed. The patient data collected regarding the risk factors associated with stridor were age, weight, size and type of airway tube (no cuff, de-inflated cuff or inflated cuff), admission diagnosis, and duration of MV. The list of possible risk factors was selected before the initiation of the study. The selection was made by the authors based on pediatric and adult literature in addition to personal experience using the Delphi method for consensus.[8]

The patients submitted to VM used plastic OTC (Mallinckrodt Medical, Ireland; SIMS Portex Ltd, United Kingdom; Rüsch GmbH, Germany). The OTC choice was standardized using the Pediatric Advanced Life Support formula: OTC internal diameter (in mm) = 4 + age (in years)/4 for uncuffed OTC; and OTC internal diameter (in mm) = 3.5 + age (in years)/4 for cuffed OTC. The choice for cuffed or uncuffed OTC was determined by the option of the attending clinician. The group of patients that used cuffed OTC had the endotracheal cuff balloon pressure controlled. The cuff balloon pressure was maintained below 20cmH_2O through all the MV length of utilization. The time of extubation during the study was determined by the care team based on clinical assessment and the use of spontaneous breathing trial.

Statistical analysis

The observed characteristics possibly associated with stridor were described in absolute frequencies and percentages, if categorical, or as mean and standard deviation, if quantitative, among patients with or without obstruction. The effects of variables on stridor were evaluated using uni-and multivariate logistic regression models. Variables with p value <0.10 in the univariate approach were included in the multivariate model. Effect sizes were presented as *odds ratio*s (OR) and 95% confidence intervals (95%CI) and p values <0.05 were considered statistically significant. Analyses were performed using the Statistical Software for the Social Sciences (SPSS), version 17.

RESULTS

A total of 148 patients used MV for more than 24 hours and were eligible for the study. Twelve of them were excluded (eight for receiving prophylactic corticosteroids and four for death before extubation attempt). Their mean age was 1.4 year (range: 3 days to 17 years). Thirty-three percent of patients were less than 1 year old. The mean weight was 16.6kg. Table 1 (136 patients) shows that PICU received predominantly clinical patients with respiratory disease (71% of the non-surgical patients).

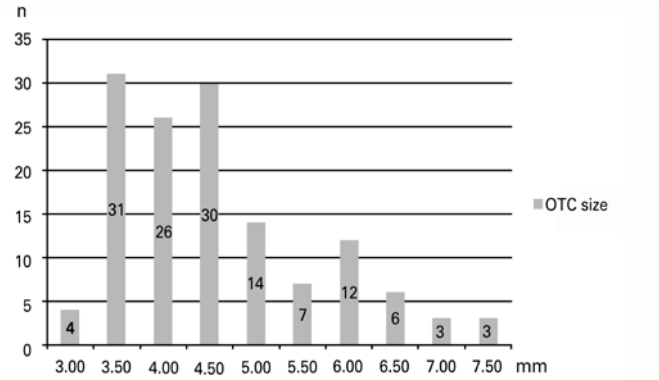
Figure 1 shows that the size of OTC most frequently used was 3.5mm. Seventy-four patients (54%) used the cuffed OTC; 19 (14%) patients used the deflated cuffed OTC. The uncuffed OTC was preferred in infants (76% uncuffed OTC *versus* 24% cuffed OTC). Moreover, among children aged over 1 year, uncuffed OTC was used in 22% and cuffed OTC in 78% of them (Figure 2).

Table 1. Demographics and characteristics of patients submitted to mechanical ventilation (>24 hours)

Characteristics	Patients n (%)
Sex	
Male	70 (51.5)
Female	66 (48.5)
Age (years)	
<1	45 (33.1)
1-2	24 (17.6)
2-6	31 (22.8)
>6	36 (26.5)
PICU admission	
Clinical	91 (66.9)
Surgical	45 (33.1)
Diagnosis	
Respiratory	65 (47.8)
Neurological	9 (6.6)
Oncological	12 (8.8)
Severe sepsis/septic shock	5 (3.7)
Surgical	45 (33.1)

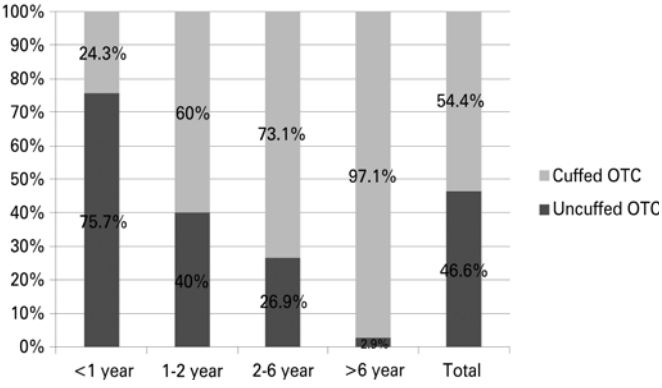
PICU: pediatric intensive care unit.

The mean duration of MV was 73.5 hours, ranging from 24 to 72 hours. Fifty- six patients (41.2%) presented with stridor after extubation. The total reintubation rate was 12.5% in patients without stridor and 19.6% in patients with stridor. There were no significant statistical differences regarding age, weight, size, and type of OTC (Table 2).



OTC size: orotracheal cannula size.

Figure 1. Size of orotracheal cannula, in millimeters, and number of patients



Cuffed OTC: cuffed of orotracheal cannula; Uncuffed OTC: uncuffed of orotracheal cannula.

Figure 2. Age distribution of cuffed orotracheal cannula and uncuffed orotracheal cannula (%)

In the univariate analysis, age of less than 12 months (p<0.037), weight under 10kg (p<0.77), and duration of MV between 24 and 72 hours (OR: 4.14; 95%CI: 1.60-10.73; p=0.001) and higher than 72 hours (OR: 5.92; 95%CI: 2.24-15.63; p<0.01) were statistically associated with stridor.

Regarding the multivariate analysis, the risk factors associated with stridor were duration of MV between 24 to 72 hours (OR: 5.40; 95%CI: 1.96-14.90; p<0.001). This risk increased if the duration of MV was greater than 72 hours (OR: 8.60; 95%CI: 2.98-24.82; p<0.001). With this analysis, the only risk factor associated with stridor in our population was the duration of MV.

Two known risk factors with an increased likelihood of determining post-extubation stridor were evaluated with special attention. The presence of cuffed OTC (regardless of being inflated or deflated) and children with less than 12 months and 10kg (infants) were not associated with increased risk of stridor in our population.

Table 2. Effects of variables on stridor using univariate and multivariate logistic regression models

	Stridor				Univariate		Multivariate	
	No		Yes		*Odds ratio* (95%CI)	p value	*Odds ratio* (95%CI)	p value
	n	(%)	n	(%)				
Sex								
Male	41	(61.2)	26	(38.8)	0.85 (0.42-1.73)	0.661		
Female	35	(57.4)	26	(42.6)				
Age (years)								
<1	22	(48.9)	23	(51.1)		0.037		0.308
1-2	11	(45.8)	13	(54.2)	1.13 (0.42-3.05)	0.809	0.93 (0.24-3.53)	0.91
2-6	19	(61.3)	12	(38.7)	0.60 (0.24-1.53)	0.288	0.47 (0.10-2.08)	0.318
>6	28	(77.8)	8	(22.2)	0.27 (0.10-0.73)	0.009	0.15 (0.02-1.16)	0.069
Weight (kg)								
<10	31	(50.8)	30	(49.2)		0.077		0.873
10-15	11	(50.0)	11	(50.0)	1.03 (0.39-2.74)	0.947	1.82 (0.45-7.45)	0.404
15-22	11	(61.1)	7	(38.9)	0.66 (0.23-1.92)	0.444	1.43 (0.28-7.35)	0.669
>22	27	(77.1)	8	(22.9)	0.31 (0.12-0.78)	0.013	1.33 (0.19-9.34)	0.773
Cuffed OTC								
No	38	(61.3)	24	(38.7)		0.291		
Deflated cuff	8	(42.1)	11	(57.9)	2.18 (0.77-6.19)	0.144		
Inflated cuff	34	(61.8)	21	(38.2)	0.98 (0.46-2.06)	0.953		
MV duration (hours)								
<24	36	(81.8)	8	(18.2)		0.001		<0.001
24-72	25	(52.1)	23	(47.9)	4.14 (1.60-10.73)	0.003	5.40 (1.96-14.90)	0.001
>72	19	(43.2)	25	(56.8)	5.92 (2.24-15.63)	<0.001	8.60 (2.98-24.82)	<0.001
Diagnosis upon admission								
Surgical	30	(66.7)	15	(33.3)		0.280		
Neurological	5	(55.6)	4	(44.4)	1.93 (0.44-8.47)	0.382		
Oncological	8	(66.7)	4	(33.3)	1.21 (0.31-4.78)	0.787		
Respiratory	33	(50.8)	32	(49.2)	2.42 (1.05-5.58)	0.039		
Severe sepsis/septic shock	4	(80.0)	1	(20.0)	0.81 (0.08-8.54)	0.858		
OTC size (median - SD)	4.7	(1.2)	4.5	(1.0)	0.82 (0.60-1.13)	0.218		

95%CI: 95% confidence interval; OTC: orotracheal cannula; MV: mechanical ventilation; SD: standard deviation.

DISCUSSION

Our findings show that the duration of MV and consequently the duration of OTC utilization were the only risk factors associated with stridor after extubation in our population. Although it could be considered an obvious conclusion, the literature remains controversial about the duration of intubation and the subsequent risk of developing complications.[2] Analyzing specifically the presence of post-extubation stridor, the duration of MV for more than 3 days was associated with increased risk for stridor in the adult literature.[9,10] Nevertheless, other authors fail to show this association, maintaining the subject in debate.[5,11,12] These considerations are important because extubation failure results in prolonged utilization of MV and is independently associated with a five-fold increased risk of death in pediatric patients.[13]

When the duration of MV is associated with stridor and used for more than 72 hours, it is often associated with increased risk.[14] In other studies, the risk is increased only after 5 to 6 days.[9,15] It is interesting to note that in our study, a duration of MV as low as 24 hours was sufficient to demonstrate significance in the presence of stridor.

Our incidence of stridor after extubation (42%) is greater than other pediatric studies.[1,2] This could be explained by the high sensitivity of our definition of stridor. All health staff of our PICU was trained to consider any noisy breathing as stridor. Sometimes, secretion and agitation after extubation can mimic airway obstruction, but as the differentiation in children is difficult, we chose to use the most sensitive definition. This definition is the one with less interobserver variability in our experience. This variability in evaluation may

contribute to inconsistent findings in assessment of risk factors and in incidence of stridor.[3,16]

Regarding gender, the adult literature indicates that females are at increased risk of developing stridor after extubation.[9,12] The smaller size of larynx of females explains this increased risk when compared to males.[17] On the other hand, in children, the male gender is associated with post-extubation airway compromise.[5] In our population, neither gender was associated with greater risk.

According to previous studies, non-surgical patients (medical patients) are at risk of developing stridor after extubation.[10] Our PICU received the majority of children with non-surgical diseases (66%). In our population, there was a clear prevalence of respiratory diseases, with more than 70% of the non-surgical patients. Nevertheless, the admission diagnosis was not associated with a higher risk of stridor.

It was expected to find in literature that children under 24 months of age would be at risk for post-extubation stridor, due to the smaller caliber of the airways and[5] we opted to also include weight as a risk factor, and both revealed that children under 12 months old and with less than 10kg had increased risk of stridor in univariate analysis. Otherwise, in the multivariate analysis each predictor would fail to show its association with stridor. It is possible that these predictors associated with infants (age <12 months and weight <10kg) could show significance if we had a larger sample.

The published studies on utilization of cuffed OTC in small children have demonstrated different and better results when compared with the standard and classical affirmation that cuffed OTC is associated with airway mucosa injury and consequently post-extubation stridor. These studies show that the use of cuffed OTC is not related with airway damage when adequate OTC diameter is used and the cuff pressure is sustained below 20mmHg.[4,18-20]

Therefore, the traditional clinical practice for the last half century that children under 8 to 10 years should use uncuffed OTC was based on experienced medical opinion and empiricism rather than scientific evidence. The assumption was that the cricoid cartilage would always be a perfectly circular structure and therefore would provide a physiologic seal with airway pressures fewer than <25cmH_2O with uncuffed OTCs.[21]

Other studies show that cuffed OTC in small children could lead to laryngeal injury and subsequent post-extubation stridor and other airway morbidity. Nevertheless, it is important to mention that some of these studies are case reports and/or studies related with wrong OTC utilization, such as oversized OTC diameters, inadequately designed cuffs, inadequate tube position, cuff overinflation, or absence of cuff pressure control.[22-26]

Regardless of the controversy about airway injury and the fear of changing traditional concepts, cuffed OTC has determinant advantages in anesthetic and pediatric intensive care use. For anesthesia, the cuffed OTC allows the use of lower flow of fresh gas and therefore, decreases atmospheric pollution by anesthetic gases, lowering the health risk for operating room personnel and decreasing the consumption of these gases, with economic implications. For anesthesia and pediatric intensive care, it decreases the risk of aspiration and improves the ventilation and end-tidal carbon dioxide monitoring with better control of air leakage.[27,28] In children with severe lung disease requiring higher mean airway pressures for lung recruitment, like in protective lung strategies of ventilation (low tidal volume and high positive end-expiratory pressure – PEEP) or high frequency oscillatory ventilation, the use of these strategies would be impossible without a cuffed OTC.[29]

One limitation of our study was not evaluating the number of intubation attempts and the location of the procedure, as it could be associated with stridor.[5] Another limitation is the design of the study, because a clinical trial would provide stronger evidence when compared with a cohort.

In contrast, our tertiary PICU has high-complexity patients submitted to liver and bone marrow transplants and cardiac surgery, but also admitting less severe patients, with a great number of respiratory diseases in previously healthy children, like bronchiolitis, laryngitis and pneumonia. Therefore, one of the strengths of this study is the analysis of the risk factors of stridor in this heterogeneous group, with the particular issue of being a private PICU, with a large sample for a single pediatric center. Another advantage is that it emphasizes the concept that days of ventilation correlate with post-extubation outcome, as previously demonstrated in the literature.[9,10,13,15]

As to OTC, our study increases the body of evidence that cuffed OTC is not associated with a higher risk of stridor in the PICU setting. Unfortunately, this study does not have sufficient statistical power to enlighten the affirmation of previous authors to support pediatric intensive care providers and anesthesiologists in the use cuffed OTC in all pediatric situations. There is a trend in the literature, with increasing number of published articles, showing that cuffed OTC should be used in all pediatric patients, but this should not be extrapolated to the pediatric intensive care setting.[6]

CONCLUSION

The main risk factor for stridor after extubation in our population was duration of mechanical ventilation greater than 24 hours. The risk increased if the duration of mechanical ventilation were greater than 72 hours. The presence of cuffed orotracheal cannula was not associated with increased risk for stridor in children, but lacked sufficient statistical power to make a recommendation in favor of or against the routine use of cuffed orotracheal cannula.

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