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MAIN ARTICLE

Incidence of post-intubation subglottic stenosis in children: prospective study

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Abstract

Objective: To evaluate the incidence of subglottic stenosis in children undergoing endotracheal intubation.

Methods: Children in the paediatric intensive care unit of a tertiary care hospital were considered eligible for inclusion if they received endotracheal intubation for more than 24 hours. After extubation, children underwent flexible fibre-optic nasolaryngoscopy. Based on this first evaluation, they were divided into two groups: 'acute normal', with mild laryngeal alterations or normal findings; and 'acute alterations', with moderate to severe laryngeal alterations. Further laryngoscopic follow up (7–10 days later) was undertaken for those children in the acute normal group who developed symptoms during follow up (after discharge from the intensive care unit), and for all children in the acute alterations group. Children were then classified into two final groups: 'normal final examination', with no chronic changes; and 'subglottic stenosis'.

Results: We included 123 children. The incidence of subglottic stenosis was 11.38 per cent (95 per cent confidence interval, 6.63–17.94 per cent). All the children who developed subglottic stenosis had had moderate to severe alterations immediately after extubation.

Conclusion: This incidence of subglottic stenosis is quite high and needs further investigation to identify risk factors.

Key words: Child; Acquired Subglottic Stenosis; Prevalence; Diagnosis

Introduction

Treatment of acute respiratory failure often requires endotracheal intubation, but this not infrequently causes complications which may be severe.[1]

The most severe long-term complication of endotracheal intubation is subglottic stenosis, characterised by a narrowing of the laryngeal lumen immediately below the vocal folds (at the cricoid cartilage). This is the narrowest and least compliant point in the infant airway because it is surrounded by cartilage.[2] Therefore, the presence of an endotracheal tube in this area, along with other factors, may cause oedema, ulceration and necrosis of subglottic structures, and may lead to the development of stenosis.[3]

The reported prevalence of subglottic stenosis has decreased in the last 30 years. Studies conducted in the 1970s reported a prevalence of 3.8–8.3 per cent.[4–7] More recent studies have reported no cases of subglottic stenosis in some series[8,9] and a very low prevalence (0.4–3.2 per cent) in others.[10–12] Higher reported prevalences (12.8–24.5 per cent) have probably been due to unusual characteristics of the study population (e.g. very low birth weight infants) and/or to greater patient survival in more recent studies.[13,14] Nonetheless, all these rates are based on retrospective studies most of which have been conducted in neonates rather than infants or older children. There are few prospective studies on this topic. A 2007 study reported a prevalence of post-intubation subglottic stenosis of 4.2 per cent in children with acute viral bronchiolitis.[15] Another study found an incidence of 2.7 per cent in patients who were intubated for different reasons.[16] However, published prospective studies show a high rate of loss to follow up, or have problems with inclusion and exclusion criteria. Therefore, the prevalence of subglottic stenosis may have been underestimated.

Other problems include the general lack of awareness of the possibility of post-intubation subglottic stenosis, and the increased propensity for respiratory infections in infant intensive care unit survivors, both of which make delayed diagnosis and mismanagement more likely. As a result, if diagnostic procedures are not performed routinely in all children after extubation, some cases of subglottic stenosis may be misdiagnosed,

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particularly those of Cotton–Myer grade 1 and 2[17] (as these grades may cause sporadic rather than continuous symptoms).[6] In addition, early diagnosis is desirable because various, promising therapies (e.g. balloon dilatation of the stenotic segment) seem to be more effective if performed in patients with acute stenosis rather than granulation tissue.

The current, prospective study was designed to determine the incidence of subglottic stenosis in all children undergoing their first endotracheal intubation in our paediatric intensive care unit.

Materials and methods

The study was approved by the ethics committee of the Hospital de Clínicas de Porto Alegre, Porto Alegre, Brazil.

Patients were eligible if they were admitted to the paediatric intensive care unit of the Hospital de Clínicas de Porto Alegre and underwent orotracheal intubation for longer than 24 hours, and if their parents or guardians signed an informed consent form.

Children were excluded if they had a history of a previous intubation, laryngeal disease, current or past tracheostomy, or were classified as terminal by the healthcare team.

Parents were interviewed in the first 24 hours after admission, and data were collected about pregnancy, delivery and co-morbidities. The intensive care team was interviewed about the patient's diagnosis. Patients were followed daily within the paediatric intensive care unit until extubation.

Flexible fibre-optic laryngoscopy was performed in the first 8 hours after extubation, with the patient in bed and conscious, and without interruption of cardiac monitoring or oxygen supply. No sedation was used apart from 2 per cent lidocaine hydrochloride gel applied to the nasal fossa and to the endoscope. The intensive care team was aware of when the examination was to be performed and was ready to help if needed. The patient was positioned with the help of the nurses, and oxygen saturation and heart rate were monitored throughout the examination. All examinations were performed by one of the authors (either CS or MMS). The endoscope was introduced into the nasal fossa in the absence of a nasogastric tube. Minor complications comprised desaturation events down to 85 per cent without the need for intervention, bradycardia with rapid recovery, laryngospasm without desaturation below 85 per cent, and mild epistaxis. Desaturation and bradycardia requiring intervention were classified as major complications.

Laryngoscopy images were recorded on videotape and then digitised to obtain video sequences and still images for each examination. Images were analysed by a blinded examiner (GK), who scored laryngeal alterations (e.g. laryngomalacia, oedema, ulceration, granulation, necrosis and stenosis of the supraglottic, glottic and subglottic regions) according to established criteria (Table I). Children were divided into two groups: (1) an acute normal group, with mild laryngeal alterations or normal findings; and (2) an acute alterations group, with moderate to severe laryngeal alterations.

TABLE I
LARYNGEAL ALTERATIONS ON INITIAL LARYNGOSCOPY: CLASSIFICATION*

Site	Mild	Moderate	Severe
Supraglottis	Oedema Hyperaemia Non-obstructive LM	Obstructive LM	
Glottis	Oedema Hyperaemia	Uni- or bilat ulceration Arytenoid granulation	Immobility IA ulceration IA granulation
Subglottis	Oedema Hyperaemia	Partial ulceration	Complete ulceration Granulation

*Defined by current study authors, based on Colice.[18] LM = laryngomalacia; bilat = bilateral; IA = inter-arytenoid

All children were followed up after discharge from the paediatric intensive care unit. Those with moderate to severe alterations on the initial post-extubation laryngoscopy (i.e. the acute alterations group), and any additional children with laryngeal symptoms during follow up, underwent a second laryngoscopic examination 7 to 10 days after extubation, and were followed up further.

The children were then divided into two final groups: (1) a normal final examination group, with normal findings on subsequent review examinations; and (2) a subglottic stenosis group. Subglottic stenosis was diagnosed on direct laryngoscopy according to the Cotton–Myer classification.[17]

Children in the subglottic stenosis group were enrolled in a follow-up programme and were treated by the otolaryngology team.

Data are reported as mean ± standard deviation for normally distributed variables, and as median (25th to 75th percentiles) for asymmetrically distributed data. Statistical analysis was performed using the SPSS software program (SPSS Ltd, Chicago, Illinois, USA). The chi-square test or Fisher's exact test was used to compare binary variables. Student's *t*-test was used to compare symmetrical continuous variables, and the non-parametric Wilcoxon–Mann–Whitney test was used for asymmetrically distributed variables. A p value of less than 0.05 was considered statistically significant.

Results and analysis

Between November 2005 and March 2010, 123 children were included in the study. Four eligible children managed in the paediatric intensive care unit were not included because their parents did not grant consent to participate.

Table II shows patients' demographic data for the two final groupings (i.e. after review of flexible fibre-optic

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laryngoscopy and follow up in the normal final examination group, and after repeat laryngoscopy in the subglottic stenosis group).

All of the patients in our paediatric intensive care unit were treated with anti-gastroesophageal reflux medication.

There were no statistically significant differences between the two final groups.

The initial flexible fibre-optic laryngoscopy examination was conducted at a mean interval of 5 hours 20 minutes after extubation (range, 15 minutes to 7 hours 50 minutes).

There were no significant complications during the examination. Only two children had desaturation episodes, of down to 88 per cent; both reversed spontaneously and the examinations were completed without further complications. These were considered minor complications.

In the first examination, 47 children (38.2 per cent) had moderate to severe laryngeal alterations (i.e. were allocated to the acute alterations group). None of the 76 children in the acute normal group developed laryngeal symptoms; therefore, none of them underwent a second laryngoscopic examination as a review.

All of the children were followed for at least six months after extubation. Of the 123 children included in the study, 14 (11.38 per cent; 95 per cent confidence interval (CI), 6.63–17.94 per cent) had subglottic stenosis. This represented 29.8 per cent (95 per cent CI, 18.1–43.9 per cent) of the 47 children in the acute alterations group. Of the 14 children with subglottic stenosis, 2 (14.3 per cent) had grade 1 subglottic stenosis, 3 (21.4 per cent) had grade 2, 6 (42.9 per cent) had grade 3 and 3 (21.4 per cent) had grade 4. None of the children with grades 1 and 2 subglottic stenosis had classical symptoms of upper airway obstruction, such as stridor or dyspnoea, during extubation follow up. Also, 3 children with grades 3 or 4 subglottic stenosis were asymptomatic until diagnosis 7–10 days after extubation. The other six children showed signs of upper airway obstruction within the first week after extubation.

Grade 1 subglottic stenosis was managed with observation alone. One child with grade 2 subglottic stenosis underwent balloon dilatation of the stenotic segment 7 days after extubation. The other 2 children with grade 2 subglottic stenosis presented later with symptoms, during upper airway viral infections, and underwent laryngotracheoplasty. All of the children with grade 3 or 4 subglottic stenosis underwent laryngeal reconstruction (i.e. laryngotracheoplasty or cricotracheal resection).

Discussion

Post-extubation flexible fibre-optic laryngoscopy performed without sedation at the bedside in a paediatric intensive care unit has recently been evaluated.[19] This technique is accurate and safe for the examination of the airways and the subglottic region. Therefore, it is a very useful method for the early diagnosis of subglottic stenosis.

In our series, there were no significant complications of flexible fibre-optic laryngoscopy that might have prevented a full examination.

Moreover, all the children who developed subglottic stenosis had moderate to severe alterations on initial laryngoscopy (performed immediately after extubation), illustrating the high degree of sensitivity of this first evaluation.

The current study is the first to prospectively evaluate the incidence of paediatric post-intubation subglottic stenosis by performing flexible fibre-optic laryngoscopy in all children. A high incidence of 11.38 per cent was found. The paediatric studies of this condition published to date have been retrospective, or prospective but with underestimated incidence rates because of losses to follow up and a lower prevalence of testing. Our incidence findings are probably more

TABLE II
PATIENT CHARACTERISTICS AT FINAL LARYNGOSCOPY

Characteristic	Group		*p*
	NFE*	SGS†	
Age (med (25th–75th centile); y)	7.40 (4.8–15.9)	11.73 (7.2–20.9)	0.93
Male sex (%)	58.7	50	0.74
Birth wt (mean ± SD; g)	2907 ± 654.51	2878.21 ± 772.94	0.88
Hosp wt (mean ± SD; g)	6635.76 ± 3021.44	7525.71 ± 3253.61	0.43
Gest age (mean ± SD; wk)	37.19 ± 4.79	37.29 ± 2.99	0.94
Vaginal delivery (%)	66.1	64.3	1.00
Diagnosis (%)			
– Pneumonia	15	18	0.95
– Bronchiolitis	63	62	0.97
– Asthma	3	2	0.93
– Meningitis	2	2	1.00
– Other	17	16	0.98
Intubation (mean ± SD; d)	8.00 ± 2.75	8.00 ± 2.55	0.99
Cuffed ETT (%)	50	50	0.99

*n = 109; †n = 14. NFE = normal final examination; SGS = subglottic stenosis; med = median; y = years; wt = weight; SD = standard deviation; hosp = hospitalisation; wk = weeks; d = days; ETT = endotracheal tube

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accurate than in previous studies, since we followed up, and performed laryngeal examinations for, all of our patients.

Cordeiro *et al.*[16] have published a prospective study of 313 infants intubated as a result of various conditions. Of these children, 58 were excluded (due to death or lack of informed consent) and 40 were lost to follow up. Post-extubation flexible fibre-optic laryngoscopy was performed for all remaining children. Of the 215 remaining patients, 2.8 per cent showed subglottic stenosis on laryngoscopy performed soon after extubation. The authors did not repeat flexible fibre-optic laryngoscopy in patients with moderate-to-severe subglottic lesions after extubation (i.e. oedema, granulation tissue and ulcerations), and therefore the incidence of subglottic stenosis may have been underestimated, as some of these lesions can evolve into subglottic stenosis in a few days.[20]

In our study, we performed repeat flexible fibre-optic laryngoscopy for all children who showed moderate-to-severe lesions soon after extubation; thus, our incidence findings are probably more accurate than those of Cordeiro *et al.*, as it is unlikely that we missed any cases.

In 2007, Jorgensen *et al.*[15] published a study on children with viral bronchiolitis who had undergone endotracheal intubation for mechanical ventilation. They found a 4.2 per cent incidence of subglottic stenosis. However, their study was retrospective and had considerable losses to follow up; furthermore, flexible fibre-optic laryngoscopy was only performed in patients with symptoms such as stridor and respiratory failure, after extubation. Those authors suggested that their observed incidence of subglottic stenosis might have been underestimated because many patients with subglottic stenosis only have symptoms in certain situations, such as during upper airway infections. Jorgensen *et al.* also reported that some patients suffered repeated laryngitis during follow up but were not re-examined with flexible fibre-optic laryngoscopy; they believed that many of these patients might have had undiagnosed subglottic stenosis.

Our study protocol directed that we perform flexible fibre-optic laryngoscopy in all children who developed symptoms of airway obstruction, so as to minimise misdiagnosis, even if no pathology had been seen during these patients' first laryngoscopic examination. However, none of our patients in the acute normal group went on to develop symptoms.

Jones *et al.*[6] described a series of five newborns who developed post-intubation subglottic stenosis but remained asymptomatic for at least six weeks; one patient was completely free of symptoms until the diagnosis. These patients presented later with intermittent or continuous stridor following an upper respiratory tract infection, and were misdiagnosed as bronchiolitis, asthma or croup. Direct laryngoscopy showed subglottic stenosis in all of them. Jones *et al.* reported that post-intubation subglottic stenosis can be completely asymptomatic in the immediate post-extubation period, and noted a general lack of awareness of the possibility of this lesion in infants. It is important to recognise subglottic stenosis in such patients, since significant airway obstruction may occur long after discharge from hospital, either due to the lesion itself or to superimposed respiratory illness.

In our series, the risk of under-diagnosis was very small because we performed flexible fibre-optic laryngoscopy in all patients and followed them for approximately six months after discharge from hospital. In our patients, the diagnosis was either delayed or missed in at least six children, who were asymptomatic after extubation and remained so in the 7–10 days until their second laryngoscopic examination. Without this second laryngoscopy, these children may well have been discharged from hospital without the correct diagnosis; they could then have become symptomatic in the course of an acute upper airway infection, or even in an emergency setting, and may have had intubation difficulties.

Since all of our patients received anti-gastroesophageal reflux medication, it is not possible to determine the role of this disease in the incidence of post-intubation subglottic stenosis.

- **Previous subglottic stenosis studies have had problems with loss to follow up and inclusion and exclusion criteria**
- **This prospective study evaluated subglottic stenosis in paediatric intensive care patients**
- **All patients underwent laryngoscopy after extubation, and again 7–10 days later if indicated**
- **The incidence of subglottic stenosis was 11.38 per cent**
- **All cases had moderate to severe laryngeal changes immediately after extubation**

Further research is needed to determine the risk factors for subglottic stenosis and thereby to identify which children should undergo post-extubation flexible fibre-optic laryngoscopy. There are no published, prospective studies which investigate risk factors and which involve flexible fibre-optic laryngoscopy performed in all children, together with long-term follow up. Until such studies are performed, the only way to diagnose all cases of post-intubation subglottic stenosis seems to be post-extubation flexible fibre-optic laryngoscopic examination of all children.

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References

1 Stauffer JL, Olson DE, Petty TL. Complications and consequences of endotracheal intubation and tracheotomy: a prospective study of 150 critically ill adult patients. *Am J Med* 1981;**70**: 65–76
2 Tucker GF, Ossoff RH, Newman AN, Holinger LD. Histopathology of congenital subglottic stenosis. *Laryngoscope* 1979;**89**:866–77
3 Joshi VV, Mandavia SG, Stern L, Wiglesworth FW. Acute lesions induced by endotracheal intubation. Occurrence in the upper respiratory tract of newborn infants with respiratory distress syndrome. *Am J Dis Child* 1972;**124**:646–9
4 Parkin JL, Stevens MH, Jung AL. Acquired and congenital subglottic stenosis in the infant. *Ann Otol Rhinol Laryngol* 1976;**85**: 573–81
5 Strong RM, Passy V. Endotracheal intubation: complications in neonates. *Arch Otolaryngol* 1977;**103**:329–35
6 Jones R, Bodnar A, Roan Y, Johnson D. Subglottic stenosis in newborn intensive care unit graduates. *Am J Dis Child* 1981; **135**:367–8
7 Papsidero MJ, Pashley NR. Acquired stenosis of the upper airway in neonates: an increasing problem. *Ann Otol Rhinol Laryngol* 1980;**89**:512–14
8 Contencin P, Narcy P. Size of endotracheal tube and neonatal acquired subglottic stenosis: Study Group for Neonatology and Paediatric Emergencies in the Parisian Area. *Arch Otolaryngol Head Neck Surg* 1993;**119**:815–19
9 Walner DL, Loewen MS, Kimura RE. Neonatal subglottic stenosis – incidence and trends. *Laryngoscope* 2001;**111**:48–51
10 Dankle SK, Schuller DE, McClead RE. Risk factors for neonatal acquired subglottic stenosis. *Ann Otol Rhinol Laryngol* 1986;**95**: 626–30
11 Ratner I, Whitfield J. Acquired subglottic stenosis in the very-low birth weight infant. *Am J Dis Child* 1983;**137**:40–3
12 Silva O, Stevens D. Complications of airway management in very-low birth weight infants. *Biol Neonate* 1999;**75**:40–5
13 Sherman JM, Lowitt S, Stephenson C, Ironson G. Factors influencing acquired subglottic stenosis in infants. *J Pediatr* 1986; **109**:322–7
14 Downing GJ, Kilbride HW. Evaluation of airway complication in high-risk preterm infants: application of flexible airway endoscopy. *Paediatrics* 1995;**95**:567–72
15 Jorgensen J, Wei JL, Sykes KJ, Klem SA, Weatherly RA, Bruegger DE *et al*. Incidence of and risk factors for airway complications following endotracheal intubation for bronchiolitis. *Otolaryngol Head Neck Surg* 2007;**137**:394–9
16 Cordeiro AMG, Shin SH, Fernandes ICOF, Bousso A, Troster EJ. Incidence and endoscopic characteristics of airway injuries associated endotracheal intubation in children [in Portuguese]. *Rev Assoc Med Bras* 2004;**50**:87–92
17 Myer CM 3rd, O'Connor DM, Cotton RT. Proposed grading system for subglottic stenosis based on endotracheal tube sizes. *Ann Otol Rhinol Laryngol* 1994;**103**:319–23
18 Colice GL. Resolution of laryngeal injury following translaryngeal intubation. *Am Rev Respir Dis* 1992;**145**:361–4
19 Smith MM, Kuhl G, Carvalho PR, Marostica PJ. Flexible fiberoptic laryngoscopy in the first hours after extubation for the evaluation of laryngeal lesions due to intubation in the paediatric intensive care unit. *Int J Pediatr Otorhinolaryngol* 2007;**71**: 1423–8
20 Benjamin B. Prolonged intubation injuries of the larynx: endoscopic diagnosis, classification, and treatment. *Ann Otol Rhinol Laryngol Suppl* 1993;**160**:1–15

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