International Journal of Pediatric Otorhinolaryngology 86 (2016) 177–182

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Post-intubation acute laryngeal injuries in infants and children: A new classification system

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ARTICLE INFO

Article history:
Received 21 February 2016
Received in revised form 23 April 2016
Accepted 28 April 2016
Available online 2 May 2016

Keywords:
Larynx
Subglottic stenosis
Granulation tissue
Ulceration
Infants

ABSTRACT

Objective: To compare the Classification of Acute Laryngeal Injuries (CALI) with other classifications to determine which of these offers the greatest sensitivity and specificity in predicting the development of subglottic stenosis.
Methods: All children intubated for the first time in the pediatric intensive care unit were included and subjected to flexible fiber-optic laryngoscopy (FFL) within 8 h of extubation. Their injuries were categorized using the CALI, as well as adapted classifications from Lindholm, Colice and Benjamin. The children were followed up to determine who developed subglottic stenosis.
Results: This study included 194 children, with a median age of 2.67 months. The sensitivity and specificity of the CALI were 90% and 73%, respectively. The CALI showed greater specificity than the adapted classifications from Colice and Benjamin ($p < 0.001$ for both), and greater sensitivity than the adapted classification from Lindholm ($p < 0.001$).
Conclusions: Based on the CALI, 90% of children who developed subglottic stenosis had moderate to severe injuries on the initial FFL. The CALI includes all injury types described by Benjamin, as well as a proposed severity scale for these lesions, and was predictive of the development of chronic laryngeal injury.

1. Introduction

Chronic laryngeal lesions after endotracheal intubation (ETI) result from acute injuries, typically observed immediately or within a few days of extubation [1–3]. Thus, the presence of certain acute injuries could predict the development of chronic lesions [4], particularly stenoses, requiring intervention, including tracheotomy, balloon dilation or laryngotracheal reconstruction.

Although new techniques for treating acute laryngeal lesions have been developed, including dilation balloons [5] and topical anti-inflammatories [6], early detection of the lesions is essential to successfully use these treatments and prevent progression to chronic injuries.

Until now, no acute injury classification system had been validated. Several classifications have been described in the literature, including classifications described by Benjamin [7], Lindholm [8] and Colice et al. [9], but a lack of knowledge about their accuracy and their overall lack of uniformity makes it impossible to compare results between them and hinders the reproducibility of research in different centers.

The classification of acute laryngeal injuries (CALI) for pediatric populations was described by the authors and used in previous studies [10–12], but was not compared to other classification systems.

The aim of this study was to compare CALI with classifications used in other studies in order to determine the most accurate classification for predicting the development of subglottic stenosis (SGS).

2. Methods

A prospective study was conducted between 2005 and 2014, which included all children between 30 days and 5 years of age subjected to ETI for more than 24 h in the Pediatric Intensive Care Unit (PICU) of Hospital de Clínicas de Porto Alegre (HCPA). Children with

This study was performed in the Otolaryngology Unit of Hospital de Clínicas de Porto Alegre.

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http://dx.doi.org/10.1016/j.ijporl.2016.04.032
0165-5876/

Table 1
Classification of acute laryngeal injuries (CALI) as mild, moderate, or severe, according to anatomical location and type of injury.

	Group 1	Group 2	
	Mild	Moderate	Severe
Supraglottis	■ Edema ■ Hyperemia		
Glottis	■ Edema ■ Hyperemia	■ Uni- or bilateral ulceration ■ Arytenoid GT	■ Inter-arytenoid ulceration ■ Inter-arytenoid GT ■ Immobility
Subglottis	■ Edema ■ Hyperemia	■ Partial ulceration (<360°)	■ Complete ulceration (<360°) ■ GT

GT = granulation tissue.

a previous history of intubation, laryngeal pathologies, craniofacial anomalies and genetic syndromes were excluded. This study was approved by the Research Ethics Committee of HCPA (number 05–266), and informed consent was obtained from the children's parents or guardians.

Flexible fiber-optic laryngoscopy (FFL) was performed with the children in their bed within 8 h after extubation without the use of sedatives. Only 2% xylocaine gel was used in the nasal cavity and around the device. All tests were recorded on DVD and later analyzed by a blinded examiner, who also evaluated frame-by-frame images from each region.

Lesions were classified according to the CALI (Table 1 and Figs. 1–5), as well as adapted classifications from Lindholm, Colice and Benjamin.

Lindholm classifies patients according to the presence and extent of ulcerations (see more details in Results – Table 4). He does not include either normal examinations or granulation tissue in his classification. Thus, we classified patients with these findings in the category "Grade I – Hyperemia and/or edema, without ulceration".

The classification from Colice considers the degree of airway obstruction to be the most important factor in each category (see more details in Results – Table 5); thus, we classified patients by the degree of obstruction rather than the type of injury.

The Benjamin classification, in turn, does not score lesion severity, but refers to all categories of lesions that may eventually develop into glottic or subglottic obstruction (see more details in Results – Table 6); thus, we categorized cases only as "presence of acute injury" and "no acute injury." Furthermore, subglottic granulation is included in the category "Granulation Tissue" (GT), in addition to the granulation arytenoids already described by Benjamin.

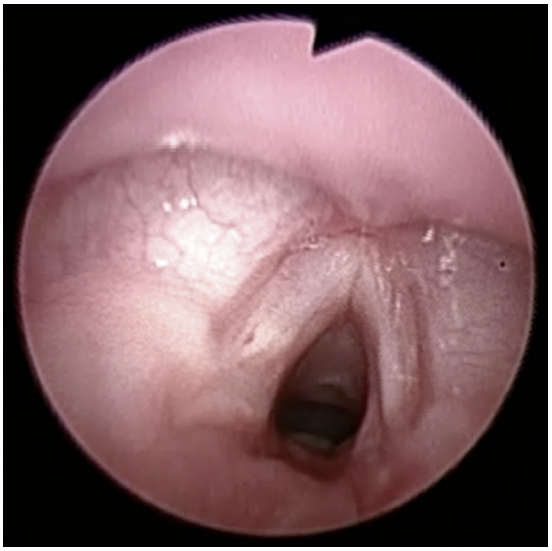

Fig. 2. Partial ulceration (CALI Group 2 – Moderate).

Children categorized into Group 1 by the CALI; i.e., without injuries or with mild injuries, were followed clinically. Children in Group 2, with moderate to severe injuries, underwent re-examination in 7–10 days. If the larynx remained injured, or if the children developed symptoms such as stridor, sternal retraction, and/or intercostal retractions during follow-up, they underwent a direct laryngoscopy under general anesthesia for better visualization of the subglottis and evaluation of SGS.

Until 2009, our treatment for subglottic GT was tracheostomy. For research project purposes, we defined 'SGS' as a child who underwent a tracheostomy because of obstructive subglottic GT and who required an open procedure later. All children who required tracheotomy subsequently required an open procedure to achieve decannulation.

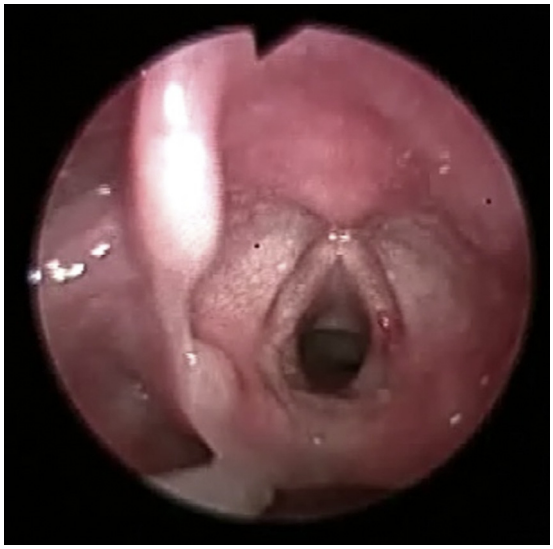

Fig. 1. Right vocal fold hyperemia (CALI Group 1 – Mild).

Fig. 3. Edema, hyperemia and granulation tissue in the supraglottis and posterior glottis, and granulation tissue in the subglottis (CALI Group 2 – Severe).