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Risk factors associated with hypoxemia during foreign body removal from airways in childhood

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ABSTRACT

Objective: The aim of this study was to analyze the association between variables associated with hypoxemia in children who underwent rigid bronchoscopy for foreign body removal.
Methods: From April 1993 to April 2011, four hundred and one children who inhaled foreign bodies were included. Apart from descriptive statistics, univariate and multivariate analyses were performed to identify risk factors related to hypoxemia.
Results: Among the patients aged up to one year, the risk of hypoxemia was five and a half times higher than for patients aged 1 or older (OR = 5.6), whereas the risk of patients who underwent foreign body removal using seed type tweezers having hypoxemia was approximately 4 times higher than that of patients who underwent this procedure with other types of tweezers (OR = 3.7). Furthermore, for each additional minute in the duration of the procedure, the risk of hypoxemia reached 4% (OR = 1.04).
Conclusion: Our results suggest that children younger than 1 year who require RB seem to be vulnerable to a higher risk of hypoxemia, especially in longer procedures in which seed tweezers are used.

1. Introduction

Foreign body aspiration (FBA) is a serious problem for children, especially among those under three years of age [1–4], and in some situations it can lead to death [1,5–7].

Rigid bronchoscopy (RB) under general anesthesia is the procedure of choice for diagnosis and removal of foreign bodies (FB) and must be done as soon as possible after the presumed or confirmed aspiration episode. Nevertheless, the procedure requires careful preparation and an experienced team in order to minimize the occurrence of technical problems, complications and even a lethal outcome [5].

Hypoxemia is the most common adverse event during RB for foreign body removal [8] and can affect about 10–20% of patients [4,8]. In general, factors associated with hypoxemia are related to the procedure *per se* (as a result of manipulation of surgical instruments in the airways or anesthetic techniques) and/or with partial or complete airway obstruction, as well as with secondary inflammatory process [8–10]. Moreover, the underlying clinical condition also seemed to affect the occurrence of hypoxemia [8]. The literature reports that hypoxemia was mainly related to the prolonged duration of the procedure [4,5,8] (OR = 1.15) [8], to the organic nature of the FB [5], especially plant seeds (OR = 2.65), [8] and to young age [8].

The present work was carried out to analyze the variables associated with hypoxemia in children who underwent RB for foreign body removal.

2. Methods

2.1. Subjects, study period and design

In this prospective study, four hundred and one children consecutively underwent RB by the first author of this paper (PFSB) at five hospitals in the city of Belo Horizonte, State of Minas Gerais, Brazil, from April 1993 to April 2011.

2.2. Inclusion criteria

All the children with suspected FBA who were examined at the above-mentioned hospitals, where RB confirmed the presence of FB in their tracheobronchial tree, were included. Also included were children that underwent RB for the differential diagnosis of

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chronic lung diseases or recurrent laryngitis, conditions in which the occurrence of FBA was occasionally found. None of those patients were hypoxemic prior to the procedure.

2.3. Procedure

RB using Karl Storz Endoskope-Germany brand bronchoscopes was performed under general intravenous and/or inhalation anesthesia with spontaneous ventilation. Neuromuscular blockade was used in some selected children. It was not possible to establish a standardized protocol for the different anesthesiology teams from all the hospitals participating in the study. Since most procedures were performed urgently and in more than one hospital, the use of the neuromuscular blockade was at the discretion of each anesthesiologist.

2.4. Hypoxemia

There is no standard protocol for appropriate saturation levels during RB for foreign body aspiration in children, due to the high number of variables such as age, age/weight ratio, size of the foreign body (organic or not), place of impact in the airway, time elapsed between aspiration and diagnosis, evolution from partial to total bronchial obstruction, among others. Then, we adopted the same criterion described by Chen et al., i.e., hypoxemia was defined when, at some moment during the procedure, oxygen saturation (SaO_2) was equal to or lower than 90% [8]. Patients who had this level of desaturation were recorded as an "event".

2.5. Study documentation form

A standardized documentation form was specially drawn up for data recording, namely age, sex, type of foreign body (organic/inorganic), time elapsed between the presumed aspiration episode and removal of the foreign body, location of the foreign body in the airways, bronchoscope and tweezers used (see Fig. 1), type of anesthetic technique, duration of the procedure and SaO_2.

2.6. Statistics

Descriptive analyses were applied to characterize the population studied. Comparisons between outcome variable (hypoxemia or not as defined above) and quantitative variables were made by means of Student-*t* tests when usual model assumptions (normality and homoscedasticity) were met. Otherwise, the Mann–Whitney test was employed. All variables were cross-tabulated with the occurrence of hypoxemia, using the chi-square test (two categorical variables with Yates correction) or Pearson's chi-square for the analysis of variables with two or more categories. If one or more of the observed values were lower than 5, the chi-square test was replaced by Fisher's exact test. The multivariate analysis was carried out through a logistic regression model to explain the occurrence of hypoxemia. All co-variables with a $p \leq 0.25$ in the univariate analysis were included in the multivariate analysis. Next, the variables were removed in a step-by-step process until the final model included only those with statistical significance (p-value ≤ 0.05). The adjustment of the final model was verified using the Hosmer–Lemeshow test. The analyses were done with the R software, version 2.7.1 (Free Software Foundation, Boston, MA, USA, 2009). A p value < 0.05 was considered statistically significant.

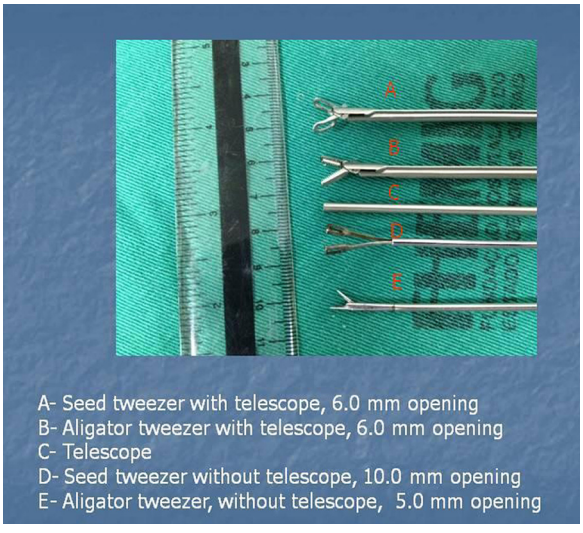

Fig. 1. Type of tweezers used for foreign body removal, with and without Hopkins telescope and the measurements of openings (nm).

2.7. Ethics

Bronchoscopy indications were based on the clinical suspicion of the attending pediatrician in view of both, the suggestive history of foreign body aspiration, and in radiological findings and upon assessment by the endoscopist, while preserving anonymity.

The project was submitted to and approved at first by the Institutional Review Board of the João XXIII Hospital of the Fundação Hospitalar do Estado de Minas Gerais, Brazil, where the study began. Later it was submitted to and approved by the Committee of Ethics in Research of the Federal University of Minas Gerais. Finally, after these two approvals, it was submitted to and also approved by the IRB of the remaining institutions.

3. Results

3.1. General characteristics of the study population

Table 1 shows the socio-demographic characteristics of the 401 children studied, the characteristics regarding the aspiration episode, the nature, and location of the aspirated foreign body, as well as endoscopic and anesthetic issues.

The median age of the subjects was 2 years and the mean age was 3.2 (DP 3.3). There was a predominance of FBA among children older than 1 year of age (88.1%). Children up to three years made up 67% of the studied population, of which 66.3% were boys. The foreign bodies were removed in up to 4 days (54.6%) after the presumed aspiration episode (ranging from 2 to 2921 days).

The FB were predominantly located in the right main bronchus (57.9%). There was a slight predominance of FB of organic nature (58.1%) that were removed during inhalation anesthesia (73.4%) with no neuromuscular blockers (52.0%). The equipment most often used was the Storz optic bronchoscope, while the tweezers most often used were the seed (54.8%) and alligator (45.6%) types and the median duration of procedure was 10 min (*ranging* between 1 and 90 min). Desaturation equal or lower than 90% occurred with 6.7% of the studied subjects.

3.2. Univariate and multivariate analysis

After the univariate analysis – in which the type of anesthesia was grouped into two categories, namely: (1) inhalation versus intravenous, regardless of the drug used, and (2) with or without a neuromuscular blocker – it was observed that among the variables described in Table 1, age less than one year old ($p = 0.006$), the organic nature of foreign body ($p = 0.008$), involvement of the right main bronchus (0.004), anesthesia with neuromuscular blockers