ORIGINAL ARTICLE

Complications in Children From Foreign Bodies in the Airway

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KEYWORDS
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PALABRAS CLAVE
Cuerpo extraño; Vía aérea; Niños; Complicaciones

Abstract
Introduction and objectives: Foreign body aspiration in childhood is a common and potentially serious problem. Complications may be the result of the aspiration episode itself, delayed diagnosis or treatment. We describe our experience in a paediatric hospital in Argentina.

Methods: We retrospectively evaluated 56 patients with complications due to foreign body aspiration recorded in the Susy Safe Project between January 2010 and November 2013. The clinical variables analysed were sex, age at time of aspiration, foreign body location and type, time elapsed from the event until object removal, extraction technique, complications, need for hospitalisation and circumstances of the event.

Results: 58.9% of the cases described occurred in males, with high presence of adults (76.8%) at the time of aspiration. The incidence was slightly higher in children older than 3 years. In 37 cases (66.1%), the foreign body was located in bronchus; sunflower seeds and ballpoint caps were the most common foreign objects. Only in 10 cases (17.9%) was the object extracted within 24 hours of the event. The most common complications were pneumonia (18 cases), granuloma (15 cases) and mucosal erosion (9 cases). Hospitalisation was necessary for 41 patients.

Conclusion: Early diagnosis and immediate control through specialised teams are essential to ensure proper treatment, usually endoscopic, without risk of complications.

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Complicaciones debido a la aspiración de cuerpos extraños en niños

Resumen
Introducción y objetivos: La aspiración de cuerpos extraños en niños es un problema frecuente y potencialmente grave. Las complicaciones pueden ser consecuencia tanto del propio episodio...
aspirativo como del retraso en el diagnóstico o de la terapéutica empleada. Describimos nuestra experiencia en un hospital pediátrico de Argentina.

**Métodos:** Se evaluaron de forma retrospectiva 56 niños con complicaciones por cuerpo extraño en la vía aérea registrados en el Proyecto Susy Safe entre enero de 2010 y noviembre de 2013. Las variables analizadas fueron el sexo, la edad en el momento de la aspiración, la localización y el tipo de cuerpo extraño, el tiempo transcurrido desde el evento hasta la extracción del objeto, la técnica de extracción, las complicaciones, la necesidad de hospitalización y las circunstancias del evento.

**Resultados:** El 58,9% de las complicaciones ocurrieron en varones, con alta presencia de adultos (76,8%) en el momento del accidente. La incidencia fue levemente mayor en mayores de 3 años. En 37 casos (66,1%) el cuerpo extraño se localizó en bronquio, siendo los más frecuentes las semillas de girasol y las partes de bolígrafo. Solo en 10 casos (17,9%) se extrajo el objeto dentro de las 24h del evento. Las complicaciones más comunes fueron la neumonía (18 casos), el granuloma (15 casos) y la erosión mucosa (9 casos). Fueron hospitalizados 41 pacientes.

**Conclusión:** Un diagnóstico precoz y un control inmediato a través de un equipo especializado son indispensables para garantizar un tratamiento apropiado sin riesgo de complicación.

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**Introducción**

El aspiración de cuerpos extraños (FB) es un problema importante y preventable causa de morbimomía y mortalidad en bebés. La mayoría de los niños expuestos a un FB son menores de 2 años, y aún más cuando las complicaciones ocurren. Los hallazgos de la introducción se muestran en la tabla 1. El objetivo principal de este estudio es determinar la incidencia, la morbilidad y la mortalidad de las complicaciones de FB en el Servicio de Endoscopia Respiratoria del Centro de Referencia para Niños Prematuros. Se analizaron 120 casos de FB en niños menores de 2 años, con un rango de edad entre 2 meses y 2 años. Los resultados mostraron una tasa de complicaciones del 35,5%, con un 10,9% de casos que requirieron tratamiento quirúrgico. En conclusión, el aspiración de FB es una situación clínica con una alta incidencia de complicaciones, lo que destaca la importancia del manejo adecuado en el manejo de estos casos.
Complications presented at the time of symptoms assessed subsequently were administered post-operatively if there were signs of mucous membrane oedema or injury.

Patients were discharged from hospital when they had been stable, without any need for oxygen, and after secondary symptoms resulting from inflammation of the airway had been resolved.

Mean follow-up time in those patients who presented with complications was 12 months. Weekly clinical controls were carried out on all of them for the first month and subsequently monthly. Patients who presented with stenosis (3 cases) or granulomas of the airway (15 cases) were assessed by endoscopy one week after FB extraction. Post-extraction X-ray controls were carried out on cases which presented radiographic pathology on admittance or when symptoms persisted.

### Results

Fifty six patients (46.7%) presented with complications resulting from aspiration of a FB (Table 1). The range of ages at the time of aspiration was from one month to 13 years of age, with most complications arising in children over 3 years (30 cases, 53.6%).

In the group of children with complications the following observations were made:

Two patients (3.6%) presented with comorbidities: one with Moebius syndrome and the other with a post-viral chronic obstructive pulmonary disease.

An X-ray was made prior to the endoscopy in 52 patients (92.6%), revealing a radiopaque FB in 12 cases, pneumonia in 18, aplectasia in 7, pleural effusion in 2 and pneumothorax, subcutaneous emphysema and pneumomediastinum in one case.

The majority of FB (66.1%) were located in the bronchial tree (37 cases), followed by location in larynx (11 cases) and trachea (8 cases).

Only in 17.9% (10 cases) was the FB extracted within 24 hours after the event. In 46.4% (26 cases) it was extracted after 15 days, delaying extraction from 1 to 4 months in 18 cases, 6 months in 3 cases, and even one and 2 years, in 2 cases.

There was a longer than 24 hour delay in the extraction of the FB in 46 cases (82.1%), because there was late diagnosis of suspected aspiration (23.9%, 11 cases) or because the initial diagnosis was erroneous (65.2%, 30 cases). In the remaining 10.9% (5 cases) the reason for delay was unknown.

In 51.8% (29 cases) the FBs were organic: the most frequent were sunflower seeds (8 cases) and peanuts (4 cases). The most common non-organic FBs were ballpoint caps (8 cases) and toys (4 cases) (Table 2). The mean age of the patients with FB which consisted of sunflower seeds and peanuts was 3.8 and 2.3 years respectively, and that of the ballpoint cap was 7.6. The mean age of the children who aspirated a piece of a toy was 2.5 years. In the patient group without complications, the most common FBs were sunflower seeds (15 cases) and peanuts (17 cases) among the organic GBs, and ballpoint caps (5 cases) and toys (2 cases) among the non organic ones.

In 50 patients (89.3%) the extraction was carried out using rigid laryngoscopy or bronchoscopy under general anaesthesia within 24 hours after hospital admittance; in one case this procedure was carried out under radioscopic control. One patient required a second bronchoscopy for the extraction which was conducted 4 days after the first one, and

### Table 1 General Characteristics of Patients With Foreign Body in the Airway.

<table>
<thead>
<tr>
<th></th>
<th>Patients with complications (No.=56)</th>
<th>%</th>
<th>Patients without complications (No.=64)</th>
<th>%</th>
<th>Total patients (No.=120)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>33</td>
<td>58.9</td>
<td>33</td>
<td>51.6</td>
<td>66</td>
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<tr>
<td>Age at time of accident</td>
<td>0-1</td>
<td>9</td>
<td>16.1</td>
<td>10</td>
<td>15.6</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>1-3</td>
<td>17</td>
<td>30.3</td>
<td>36</td>
<td>56.3</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>3-6</td>
<td>15</td>
<td>26.8</td>
<td>5</td>
<td>7.8</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>&gt;6</td>
<td>15</td>
<td>26.8</td>
<td>13</td>
<td>20.3</td>
<td>28</td>
</tr>
<tr>
<td>Location of FB</td>
<td>Larynx</td>
<td>11</td>
<td>19.6</td>
<td>2</td>
<td>3.1</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Trachea</td>
<td>8</td>
<td>14.3</td>
<td>8</td>
<td>12.5</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Bronchium</td>
<td>37</td>
<td>66.1</td>
<td>54</td>
<td>84.4</td>
<td>91</td>
</tr>
<tr>
<td>Type of FB</td>
<td>Organic</td>
<td>29</td>
<td>51.8</td>
<td>44</td>
<td>68.8</td>
<td>73</td>
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<tr>
<td></td>
<td>Non organic</td>
<td>27</td>
<td>48.2</td>
<td>20</td>
<td>31.2</td>
<td>47</td>
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<tr>
<td>Time from event to extraction</td>
<td>&lt;1 day</td>
<td>10</td>
<td>17.9</td>
<td>17</td>
<td>26.6</td>
<td>27</td>
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<tr>
<td></td>
<td>2-7 days</td>
<td>8</td>
<td>14.3</td>
<td>23</td>
<td>35.9</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>8-15 days</td>
<td>12</td>
<td>21.4</td>
<td>8</td>
<td>12.5</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>&gt;15 days</td>
<td>26</td>
<td>46.4</td>
<td>16</td>
<td>25</td>
<td>42</td>
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<tr>
<td>Extraction technique</td>
<td>Rigid endoscopy</td>
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<td>91.1</td>
<td>64</td>
<td>100</td>
<td>115</td>
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<td></td>
<td>Flexible endoscopy</td>
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<td>1.8</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
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<td></td>
<td>Others</td>
<td>4</td>
<td>7.1</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Presence of an adult</td>
<td></td>
<td>43</td>
<td>76.8</td>
<td>44</td>
<td>68.8</td>
<td>87</td>
</tr>
</tbody>
</table>

FB: foreign body.
another patient (1.8%) underwent a fibre optic bronchoscopy following poor rigid bronchoscopy outcome. In 2 patients (3.6%) the object was eliminated by coughing and in another 2 by using the Heimlich manoeuvre.

A total of 78 complications were recorded, with 17 different types being identified. Each patient presented with 1–6 complications, and the most common association was: granuloma and atelectasia (3 cases).

The most frequent complications were pneumonia (18 cases, 32.1%), followed by granulomas (15 cases, 26.8%) and mucosal erosion (9 cases, 16.1%) (Table 3: Figs. 1–3). There were neither fatal cases nor complications from the endoscopic procedure.

In 76.8% of cases (43 cases) an adult was present at the time of the accident. The majority occurred whilst the child was playing (26 cases, 46.4%) or eating (18 cases, 32.1%). Forty one patients (73.2%) were hospitalised during one to 30 days, 31 cases (75.6%) for under 72 hours.

### Discussion

There may be serious consequences from aspiration of a FB, including brain damage from anoxia or death. Whilst the data regarding the type of FB is almost always documented, there are relatively few articles which present details on the complications.  

#### Epidemiology

FB aspiration is mainly observed in children under 3 years of age, and in males. In our cases, 58.9% of the complications occurred in males, with the incidence being slightly higher in children over 3 (53.6%).

Although a recognised greater risk of FB aspiration in children with swallowing disorders exists, the majority of cases present in children without underlying medical conditions. None of our patients presented with swallowing disorders.

#### Delay in Diagnosis

The most important factor for diagnosis is the presence of a clinical history of choking. The background of the choking episode should be sought through a thorough anamnesis. Radiological investigation may help to confirm the aspiration, but must not be used to exclude it, since the majority of FBs are radiotransparent.

When the diagnosis of FB aspiration is delayed, the risk of complications and death are raised. Delay of over 24 hours is associated with a risk of complications which is 2.5 times higher than when there is early diagnosis.

In our cases, the time which ran from aspiration to FB extraction was greater than 7 days in 67.8% of children who presented with complications (38 cases), whilst in children without complications the delay was longer than seven days in 37.5% (24 cases).

The delay in diagnosis and therapy was attributed to parents who did not attend the hospital consultancy (absence of witnesses, children who did not admit the aspiration for fear of being punished, absence of symptoms after the choking episode), initial erroneous diagnosis due to insufficient knowledge of possible symptoms of a FB in the airway, parents who did not admit to a history of choking because they had not been listened to by their doctor in initial consultation, and the need to refer the patient due to lack of equipment and experience for bronchoscopy in children.

The responsibility for delay in diagnosis and therapy thus falls on the doctors and the parents or carers.
Complications in Children From Foreign Bodies

Figure 1  Right pneumonia (A) and left collapsed lung (B) from ballpoint cap. (C) Serious breathing difficulty caused by a grain of corn in the right main bronchus.

Extraction Technique

Some of the FBs were expulsed through protective reflexes such as coughing (2 cases), or medical manoeuvres (2 cases), but a significant percentage (92.9%) impacted in the airway and the patient was taken for medical consultation with different clinical symptoms and differing degrees of suspected aspiration by the family.

Rigid bronchoscopy under general anaesthesia is the best diagnostic and therapeutic method. It provides safe ventilation, a better exposure to the FB, and enables different sized pincers to be used. It must be carried out without delay once optimal conditions have been achieved: trained personnel, appropriated instruments and a period of fasting (save in cases of emergency). The anaesthesia is inhaled, with spontaneous respiration (without relaxation). The flexible bronchoscopy may help patients with troublesome intubations and with a FB located in the periphery of the lung. In our study, in one patient (1.8%) with the FB located in the periphery of the lung (grass) a fibre optic bronchoscopy was performed to extract the FB.

The longer the FB remains in the airway the more endoscopic examination in the airway is impeded due to the appearance of oedema and granulomas which hinder the location of the FB and lead to haemorrhaging when it is touched. In these cases it is a good idea to carry out

Figure 2  Needle in bronchus. (A) Chest X-ray (circle). (B) Granuloma bronchial which obscured visualisation. (C) Extraction under radioscopic control.
treatment with antibiotics and corticoids, and attempt extraction again after 48 hours. In our series, the need for a second intervention corresponded to a patient (1.8%) who was diagnosed after one month.

Location of Foreign Body

The location of the FB depends on the size and shape of the object and the position of the child during inhalation, with the most frequent being in the bronchus. Whilst large objects are often the cause of serious laryngeal obstruction, smaller objects responsible for the majority of FB events, are able to pass through the larynx and impact on the distal airway.5,12

In our series, both in children with and without complications, the majority of FB were located in the bronchial tree. 84.6% of laryngeal FB presented in children who had complications.

Type of Foreign Body

Seeds and dried fruits are the most frequently reported FB, and also the most frequently involved in the cases which present complications and require hospitalisation.12,13 In our series these represented 35.7% of FBs associated with complications, with the most common being sunflower seeds and peanuts. These were followed in frequency by ballpoint caps (14.3%).

FBs of vegetable origin lead to earlier complications than non organic ones. Due to their oily content they produce a serious inflammatory reaction in the bronchial tree (lipoid pneumonia), which contributes to early obstruction of the airway whilst making the identification and removal of the object more difficult.12-14 Seeds which become hydrated (bean, corn) should be extracted as soon as possible, since when they absorb moisture they increase in size and this may obstruct the airway and impede extraction.15 Other FBs do not get stuck and may lead to granulomas (peanut).7

Complete obstruction of the airway due to a FB is an emergency case. Large FBs, such as sausages, can get stuck at the supraglottic level, and these are the most common cause of choking on food.7 In our series, 2 of the children presented with severe laryngeal obstruction from sausages. Spherical or cylindrical FBs are equal in volume and more dangerous since they adapt to the shape of the airway (grapes, olives).5,7,16 Soft or malleable FBs adapt to the walls and may be obstructive even in low volume (a rubber balloon, a fragment of latex).7 Hard food stuffs with properties of high elasticity or lubricity are also a major risk.12,17

Whilst peanuts and walnuts are the most frequent cause of lesion, those FB most often associated with fatal outcomes are sausages, followed by hard sweets and grapes.5,12,17 Death-inducing FBs may also be impacted in
the supraglottis, the carina, the tracheal lumen, or the main bronchus.\textsuperscript{3,4} In our series there were no fatal cases nor aspiration of grapes, olives, hard sweets or fragments of latex.

Other particularly dangerous FB are objects with sharp edges (such as a needle, tacks and bones, which were present in our series), with a major associated risk of laceration and perforation,\textsuperscript{18} and the disc battery. The aspiration of a disc battery is exceptional, since it most commonly passes through the digestive system. However, should this occur, it becomes an emergency due to the seriousness and rapidity of lesions caused.\textsuperscript{19}

Complications

The occurrence of complications reported in literature varies from 10\% to 20\%, with pneumonia being the most frequently reported.\textsuperscript{3,10} In our series of 120 children attended for FB in the airway, 56 (46.7\%) presented complications. This difference may be due to the fact that the term “complication” is defined differently depending on the different authors and that our service is a centre of reference in infant airways. A key point is the delay in the extraction of the FB. In Foltran et al.’s review the delay over 24 hours in 40\% of cases was associated with a 15\% incidence of complications.\textsuperscript{3} In our series of 120 patients, the delay was greater than 24 hours in 77.5\% of cases.

Pneumonia was the most standard complication (18 cases, 30.3\%). Obstruction of the bronchial lumen by a FB and the retention of distal secretions to it led to secondary infection. Two children (3.6\%) presented with pleural effusion associated with pneumonia.

This was followed in frequency with granulomas (15 cases, 26.8\%). Granulomas appear in general when the FB has remained for over a week.\textsuperscript{15} In these cases, the FB may be obscured, and extraction is difficult, and it may even be necessary to apply more than one attempt to extract the FB, or the use of a radioscopic guide.

Mucosal erosion from decubitus or compression of the FB was observed in 16.1\% (9 cases), and atelectasias, in 12.5\% (7 cases). The atelectasia originates from occlusion of the bronchus by the FB, the oedema and/or granulation tissue, which impedes the entry and exit of air, oxygen to the alveoli is reabsorbed and the section involved loses volume, retracts and collapses. Following extraction of the FB, patients with atelectasias presented with pulmonary re-expansion oedema after bronchial lavage and secretion aspiration.

Six patients (10.7\%) presented with laryngeal oedema and 5 patients (8.9\%), with serious difficulty breathing with a need for intubation. Four were intubated prior to extraction of the FB and one afterwards due to the development of acute post-obstructive pulmonary oedema. Three patients (5.4\%) stopped breathing due to occlusion of the laryngeal (sausage), tracheal (dried fruit) and main bronchus (ballpoint cap) lumen. None of the patients suffered from neurological damage.

Two patients (3.6\%) with a history of over 6 months with a FB in the airway (sunflower seed and ballpoint cap) presented with bronchiectasis. FB retention time is the key risk factor in the development of bronchiectasis. If a patient presents after over one month of aspiration, they must be assessed with computarised tomography after extraction of the FB due to the possibility of bronchiectasis and to distinguish reversible pulmonary changes from irreversible ones.\textsuperscript{14}

Two patients (3.6\%) presented with haemoptysis, from a grass seed in the bronchus and plastic in the larynx. The coughing of blood was spontaneously resolved following removal of the FB. After lower respiratory tract infection, aspiration of FB is the second most frequent cause of haemoptysis in children.\textsuperscript{11} Bleeding is the outcome of the mechanical trauma on the respiratory epithelium or the inflammatory reaction, particularly in vegetable type FBs.\textsuperscript{11}

Two patients (3.6\%) presented with secondary convulsions to the hypoxia resulting from the tracheal and bronchial obstruction respectively.

Subglottic stenosis was observed in 2 patients (3.6\%), and bronchial stenosis in another. These were resolved with endoscopic dilation. The mucosal lesion due to sharp edges (spring and chicken bone in the larynx) and/or pressure induced by the FB and resulting infection (piece of toy in the bronchus) were the main contributing factors to the stenosis.

One patient (1.8\%) presented with subcutaneous emphysema, pneumomediastinum and pneumothorax, which required pleural drainage, with a significant improvement being noted 3 days after removal of the bronchial RB. Pneumomediastinum and subcutaneous emphysema resulting from aspiration of a FB are very infrequent, with few cases being reported (0.8\%–5.8\%).\textsuperscript{12} This is due to the sudden increase of intra-alveolar pressure produced by the alveolar rupture, leading to the release of air.\textsuperscript{21}

A mobile FB is dangerous. The longer the FB remains in the bronchial tree the greater the chances are of it becoming dislodged from the bronchus and impacting the larynx, with risk being higher in non organic FBs (in organic FBs, the greater inflammatory reaction tends to immobilise them).\textsuperscript{13} In our series one patient presented with right pneumonia with pleural effusion and later with left pneumothorax, prior to the removal of the FB (ballpoint cap).

Other reported complications in literature are: anoxic encephalopathy, emphysema and pulmonary abscess, transcutaneous expulsion of FB, migration to pleura, peri-cardium or peritoneum (ear of wheat).\textsuperscript{2,10,15} Despite the fact that rigid bronchoscopy is a safe technique, it is not risk-free. Complications have been described (0.9\%–25.9\%) such as pneumothorax, pneumo-mediastinum, haemoptysis, laryngeal oedema, bronchial stenosis, tracheal-bronchial fistulas and even death.\textsuperscript{14,15} In our series there were no complications from endoscopic procedure, nor did the need for tracheotomy or thoracotomy arise (1.6\%–27\% reported in the literature).\textsuperscript{15}

Death is the most serious of complications. Although the majority of children with FB aspiration survive, several die, either due to obstruction of the airway (resulting in choking or reflexive cardiac arrest) or as a result of complications (pneumonia, severe haemoptysis).\textsuperscript{6,14} Deaths also occur due to blind finger palpitation to remove pharyngeal FBs and impacting the object in the larynx\textsuperscript{25} and due to the impacting of the FB in the oesophagus with compression of the airway.\textsuperscript{6}

Several authors report a mortality rate of 4\%–7\%.\textsuperscript{20} Others report hospital mortality below 1\%–2\%.\textsuperscript{1} In our hospital there were no deaths, but we believe that a considerable
number of patients die before they receive any medical attention.\(^1\)

### Circumstances of the Event

The majority of episodes of choking occur during meal or playtime and generally occur under adult supervision (76.8%). The high presence of adults during FB aspiration proves that primary prevention plays a key role in preventing this type of injury.

### Prevention

The best treatment is prevention, with an increase in parent and carer education. In the study carried out by Higuchi et al. it was observed that a considerable number of mothers lacked awareness of FB aspiration and highlighted the importance of offering the appropriate information, particularly to mothers with children under 12 months and first time mothers.\(^26\)

In all visit to the paediatrician information should be made available regarding appropriate food for the age of the child, risk situations and control of access to dangerous objects.\(^8\) Doctors play a major role in prevention by offering information to the community and also in identifying children with a history or symptoms indicative of FB aspiration and by referring them quickly to hospital with experience in child bronchoscopy to prevent late diagnosis and complications.\(^8\)

The doctors involved in primary care should be trained so that complications resulting from delay in FB extraction may be reduced. It is also important to establish programmes on how to handle obstruction of the airway and promote strict standards for the toy manufacturing industry, the design of stationary articles (pens) and safe recipients.\(^8,16\)

### Conclusions

The incidence of complications due to FB aspiration was high, and higher when the delay in FB extraction was over 7 days. Pneumonia was the most frequent complication.

Rigid endoscopy was a safe and effective procedure in the treatment of FB in the airway in children.

Early diagnosis and immediate control by a specialised team are essential for ensuring correct treatment, which is generally endoscopic, without any risk of complication.\(^4,24\)

### Conflict of Interests

The authors have no conflict of interests to declare.

### References