Review Article

Review of tracheobronchial foreign body aspiration in the South African paediatric age group

Tamer Ali Sultan[1,2], Arjan Bastiaan van As[1]

[1]Trauma Unit, Division of Paediatric Surgery, Red Cross War Memorial Children's Hospital, University of Cape Town, Cape Town, South Africa; [2]Paediatric Surgery Unit, Department of General Surgery, Menoufia University, Shebeen El-Kom, Egypt

Contributions: (I) Conception and design: All authors; (II) Administrative support: All authors; (III) Provision of study materials or patients: AB van As; (IV) Collection and assembly of data: TA Sultan; (V) Data analysis and interpretation: TA Sultan; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Prof. Arjan Bastiaan van As, MBChB, FCS(SA), MMed, MBA, PhD. Trauma Unit Red Cross War Memorial Children's Hospital, Division of Paediatric Surgery, University of Cape Town, Cape Town, South Africa. Email: sebastian.vanas@uct.ac.za.

Abstract: Children, and in particular young children under the age of three, are the most vulnerable for aspiration and ingestion of foreign bodies (FBs). The Red Cross War Memorial Children's Hospital in Cape Town is the only children's hospital in South Africa and is unique in having a dedicated trauma unit for children under the age of 13 as part of its institution. Core activities of Childsafe South Africa (CSA), located at the hospital, are data accumulation and interpretation, development of educational programmes, health inculcation and advising in legislation involving child health. To achieve this task, CSA works in close co-operation with government, industry, non-governmental and community predicated organisations, community groups and individuals. A database of all children treated for trauma at CSA has been maintained since 1991; it currently contains detailed information of over 170,000 injuries in children under the age of 13. This review consists of a literature review combined with data from our database and aims to provide information on our experiences with tracheobronchial aspiration of FBs in children.

Keywords: Aspiration; bronchus; children; trachea; South Africa; review

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Introduction

Children, and in particular the very young, are the most vulnerable for aspiration and ingestion of foreign bodies (FBs) (1).

Although the spectrum of FBs varies from country to country, depending on the diet and customs of the population, the most common foreign body aspiration (FBA) causing injuries are from diminutive food items (2). Case reports, cases series and data emanating from death certificates testify that nuts and seeds could represent an earnest threat being not only the most documented FB, but also frequently involved in cases presenting with complications and requiring hospitalization (3).

Aspiration of a FB into the air passages conventionally occurs in older infants and toddlers. Boys are affected more than girls in a ratio of 2:1 (4).

FBA is a prevalent cause of pathology in children, particular in those younger under 3 years of age. It has been estimated that in the year 2000, FBs, either ingested and/or aspirated were responsible for over 17,000 visits to health facilities of children under the age of 15 in North America (5).

While the mortality has been typically high in previous centuries, (almost a quarter of all cases), with the advance of modern bronchoscopy techniques, current mortality has significantly declined over the last 25 years (6).

It has been estimated that the vast majority of FB aspiration takes place in children under the age of 4, while the peak incidence seems to occur between the age of 12 and 24 months (7-14). These children can move around

Table 1 Location of FBA in children

Location	Percentage (percentages rounded off)
Larynx	3
Trachea and carina	13
Right lung (total)	60
Main bronchus	52
Lower lobe bronchus	6
Middle lobe bronchus	<1
Left lung (total)	23
Main bronchus	18
Lower lobe bronchus	5
Bilateral	2

and are able and prone to explore the outside world with their mouth, putting any object they can get hold of within their mouth, while they still lack proper molars to grind objects to smaller (and less dangerous) pieces.

Other predisposing factors for FBA at this young age include access to unsuitable foods or tiny objects, all kinds of other active behaviour while eating. Above all, children are far more vulnerable to aspiration of a FB due to the small diameter of their airway, prone to easily be obstructed (15). In adolescents and adults, neurodevelopmental delays (16), low level of consciousness, and drugs and alcohol will increase the risk of FBA (17).

In paediatrics, commonly aspirated FBs are nuts, victual particles, equipment, and parts or bits of toys, peanuts (36–55% of FBs aspirations in civilized countries), seeds and popcorn (9-11,13,14).

Aliment parts are the most widely recognized objects aspirated by newborns and babies, while non-food particles as pins and coins are mostly present in elder kids (2,18-20). Inflatables toys or other objects (e.g., inflated gloves or condoms) are the most prevalent objects in lethal FBAs (15).

Factors that make FBs more perilous include roundness (round objects are most liable to cause consummate airway obstruction and asphyxiation), failure to break asunder facilely, compressibility, and smooth, slippery surface (15). The effects of tablet aspiration depend on the properties of the medication. Certain medications such as iron or potassium may dissolve in the airways and cause excruciating inflammation and eventually stenosis, so early diagnosis and timely extraction is consequential to minimize long-term consequences (21,22).

The majority of FBAs in children are located in the bronchi (7,11,23). Laryngeal and tracheal FBs are less common. In a large case series of FBA aspirations in children, the sites of the FB are shown in *Table 1* (7).

Although most aspirated FBs are located in the bronchi, sizably voluminous, bulky FBs (e.g., aliment), or those with sharp, aberrant edges may also become lodged in the larynx (11,24). This is particularly prevalent in infants younger than one year. Tracheal narrowing or impotent respiratory effort may predispose to tracheal FB (11). Compared with bronchial FBs, laryngo-tracheal FBs are associated with incremented morbidity and mortality (24,25).

Clinical presentation

Youngsters frequently move and giggle while they are eating and don't focus on masticating or gulping. In addition, the neurological-motor mechanism controlling swallowing may also be still underdeveloped, disqualifying it to give appropriate control to eschew nourishments or different materials to enter air passages.

Roughly 75% of upper airways FBs in the children happen in kids less than 3 years. Most FBs are sufficiently small to pass to the trachea.

Because of the wide calibre of the trachea contrasted with the cricoid cartilage, only few FBs lodge within the trachea. Consequently most FBs will pass through the trachea to lodge within the bronchi.

In children less than 5 years, non-food particles are less common than food particles, while in elder children non-food particles dominate.

A detailed history and a thorough clinical examination are very important in assessing children that potentially aspirated a FB (26).

It is not uncommon following aspiration of a FB that a "silent era" to occur. Only when time progresses, the FM may cause erosion and/or inflammation. This condition could be accompanied by fever, cough discomfort and haemoptysis. Serious lung infections may develop later (4,26).

The signs and symptoms of FBA vary according to the location of the FB (27,28) (*Table 2*).

Delayed diagnosis—patients who present days or weeks after the aspiration often develop symptoms due to complications cognate to the presence of the FB, such as infection and inflammation of the airway. Thus, they may present with fever and other signs and symptoms of pneumonia. In the absence of a history of choking, FBA may not be suspected. These patients with occult FBA

Table 2 The signs and symptoms of FBA vary according to the location of the FB

Location	Signs and symptoms
Laryngotracheal	Relatively rare (5–17% of FBs) but are categorically liable to be life-threatening. Symptoms include stridor, wheeze, and dyspnea, and sometimes hoarseness. FBs in this location are most liable to present with acute respiratory distress, which must be addressed promptly. Laryngeal FBs or sizably voluminous perforating FBs with sharp edges withal may cause symptoms cognate to the esophagus
Large bronchi	The customary symptoms are coughing and wheezing. Hemoptysis, dyspnea, choking, shortness of breath, respiratory distress, decremented breath sounds, fever, and cyanosis may withal occur (7,8,29)
	The right main bronchus is the most common location (45–55% of FBs), followed by left bronchus (about 30–40% of FBs), and bilateral bronchi (1–5%)
Lower airways	Children with these FBs may have little acute distress after the initial choking episode

FBA, foreign body aspiration.

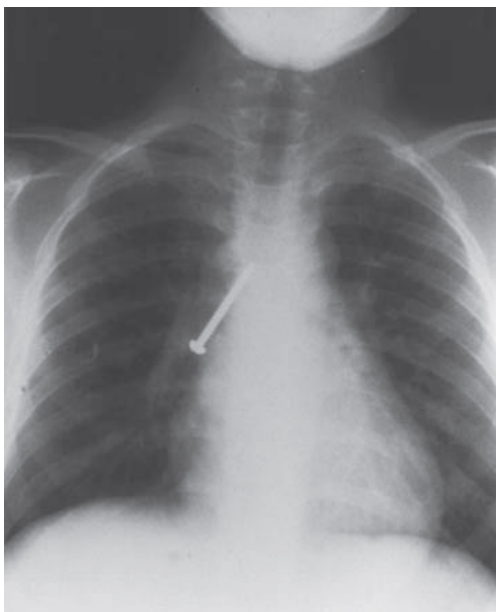

Figure 1 Aspirated metal screw positioned within the right main bronchus and with the pointed tip in the trachea while the blunt end pointing downwards (the most common orientation) (4).

may amend with antibiotic therapy. However, the infiltrate on chest radiograph customarily does not resolve, and recurrence of pneumonia is common.

One reason for delay in diagnosis is that children with lower airway FBs may present with subtle or nonspecific symptoms (30). As a result, they may come to medical attention only when they develop dyspnoea, wheezing, chronic cough, or recurrent pneumonia (31).

Other factors contributing to diagnostic delay include unwitnessed aspiration, a decision by the parents or physician not to pursue evaluation once the acute choking episode has resolved, and misinterpretation of symptoms as evidence fortifying the diagnosis of *de novo* pneumonia, asthma or asthma exacerbation, or bronchiolitis (11,30,32).

Life-threatening FBA—if a child presents with consummate airway obstruction (i.e., is unable to verbalize or cough), dislodgement utilizing back blows and chest compressions in infants, and the Heimlich manoeuvre in older children, should be endeavoured. In contrast, these interventions should be eschewed in children who are able to talk or cough since they may convert a partial to a consummate obstruction (11). For the same reason "blind" sweeping of the mouth should be evaded.

The recommendations of the American Heart Sodality (AHA) regarding interventions for choking represent the standard in acute life-threatening events (33).

Diagnosis

Posteroanterior and lateral chest radiographs (*Figure 1*) are acquired to assess a youngster suspected of FB aspiration. Posteroanterior and lateral neck radiographs are subsidiary for distinguishing tracheal radiopaque particles. Chest radiographs on respiration can be of use. Expiratory radiographs can demonstrate air which caught underneath the obstacle, bringing about emphysema of the included part; contralateral shift of the mediastinum can also be seen.

Radiographs may demonstrate any other inflammatory lung problems. In any case, endoscopy remains the gold standard for both discovery of FBs and treatment by extraction (4,26). Flexible rather than rigid bronchoscopy may be utilized for diagnostic purposes in cases in which the diagnosis is obscure, or if the FBA is known but the location

Table 3 The most common radiological findings after aspiration of a foreign body in the lower airways (39,40)

Radiological finding	Mechanism
Hyperinflated lung (lucency distal to the obstruction)	This is caused by partial airway obstruction with air trapping, such that air passes with inspiration, but not with exhalation
Atelectasis	This is customarily caused by consummate obstruction of an airway, since air is resorbed from the distal alveoli over time
Mediastinal shift	The mediastinum inclines to shift away from the lung field containing the foreign body
Pneumonia	Infection often develops distal to an obstructed airway. Consequently, a consolidated infiltrate is withal a possible finding. Pulmonary abscesses and bronchiectasis are tardy manifestations of a retained airway FB

of the object is obscure (34).

Plain radiographic evaluation of the chest may or may not be helpful in establishing the diagnosis of FBA, depending upon whether the object is radio-opaque, and whether and to what degree airway obstruction is present. The diagnosis of FBA is readily established with plain radiographs when the object is radio-opaque (only about 10% of FBs). However, most objects aspirated by children are radiolucent (e.g., nuts, aliment particles) (35), and are not detected with standard radiographs unless aspiration is accompanied by airway obstruction or other complications (7,35-37). As a result, common findings on radiography do not rule out FBA, and the clinical history is the main determinant of whether to perform a bronchoscopy (38).

In children with lower airway FBA, the most prevalent radiographic findings are listed in *Table 3* (27,28,41,42).

The chest radiograph is normal in at least 30% of cases (7,41,43). The sensitivity of chest films has been reported to be between 68% and 76%, and the specificity between 45% and 67% when evaluating for FBs in the airway (44). Ideally, both inspiratory and expiratory radiographs should be obtained, if this is possible, because this may increase the sensitivity for detecting a radiolucent FB.

In adolescent children in whom it is arduous to obtain expiratory radiographs (either because they are tachypneic or because they cannot cooperate), left decubitus films may simulate expiratory radiographs. However, two retrospective studies suggested that these films did not integrate diagnostic value, at least as routinely performed (45,46).

If a laryngotracheal FB is suspected predicated on symptoms (stridor, wheeze, and dyspnoea, and sometimes hoarseness) a neck radiograph should be performed. These should include posteroanterior and lateral views, with the arms and shoulders situated inferiorly and posteriorly to optimize the image of the larynx and trachea. Even if the FB is radiolucent, these films may suggest the diagnosis if they show a subglottic density or swelling (25).

CT is a possible diagnostic option for patients who are asymptomatic or symptomatic but stable, who have normal or inconclusive plain radiographs but a perpetual clinical suspicion of FB aspiration. However, this imaging is only subsidiary if the provider judges that negative imaging would be adequate to preclude bronchoscopy (47,48).

Treatment

An emergency endoscopy is obligatory in critical situations. After the patient is anaesthetised in recumbent position the neck should be gently extended. We advocate the use a laryngoscope to also inspect the larynx as part of the bronchoscopy.

The ventilating endoscope is than carefully introduced into the trachea, while ventilation continues. All air passages are carefully examined, and the FB abstracted through or with the bronchoscope.

FB extraction will fail with bad vision or sometimes when fragmented particles have moved more distally. These are sometimes amenable for extraction utilising a Fogarty catheter. In very rare cases more drastic procedures may be require such as bronchotomy or resection of the lung.

Corticosteroids or bronchodilators may be indicated to decrease oedema. Adrenaline can also be useful in certain circumstances. Chest radiographs are mandatory in the follow-up for the identification of pneumothorax and/or air in the mediastinum following FB extraction (4,26).

FB extraction

If FBA is known to have occurred or is vigorously suspected, rigid bronchoscopy is the procedure of choice to identify

and extract the object (29,34,49). Rigid bronchoscopy sanctions control of the airway, good visualization, manipulation of the object with a wide variety of forceps, and yare management of mucosal haemorrhage (20,50-52).

Bronchoscopy is successful in extracting the FB in approximately 95% of cases, with a very low complication rate of less than 1% (7,53,54). Thoracotomy is rarely indicated in those cases in which FBs can be visualized but cannot be extracted by means of a rigid bronchoscope.

FB extraction should be performed by an experienced operator to minimize the jeopardy of complications. Unsuccessful attempts to remove the FB may push it into a distal position, making them more arduous to retrieve. Disintegration or dislodgement of all or part of the FB, or a fragment of the FB, into the main bronchus of the contralateral lung are potentially lethal complications if the pristinely involved bronchus remains obstructed by inflammation or residual FB (55). Major complications of FB extraction include pneumothorax, hemorrhage, and respiratory apprehend, but they occur infrequently.

Alternatively, flexible (rather than rigid) bronchoscopy is utilized to extract the FB in some centers with experience in this technique (28,51,56,57). This technique customarily is circumscribed to older adolescents or adolescent adults. Potential advantages of utilizing flexible bronchoscopy for FB extraction are avoidance of general anaesthesia and the facility to reach sub-segmental bronchi.

In a large case series, the FB was successfully extracted by flexible bronchoscopy in 91% of patients (28). The main disadvantage of flexible bronchoscopy for FB abstraction is the peril of dislodging the FB and further compromising the airway. Because of these concerns, the American Thoracic Society (ATS) states, "*In general*, *rigid instruments are superior for detailed anatomic assessment of the larynx and cervical trachea and for operative manipulation*, *principally foreign body extraction*" (52). Flexible bronchoscopy is commonly utilized by most centers for management of FBA in adults.

If there is a suspicion for multiple diminutive FBs or fragments, we recommend performing a flexible bronchoscopy after FB abstraction, to evaluate the entire tracheobronchial tree (31,58).

Complications

When FBA is diagnosed soon after the event, there is customarily little damage to the airway or lung parenchyma. The longer the FB is retained, the more likely are complications (e.g., atelectasis, post-obstructive pneumonia). A FB that causes chronic or recurrent distal infection may lead to bronchiectasis (31,39,40,59,60). This complication should be treated after the FB is abstracted. Cultures obtained during bronchoscopy guide the initial antibiotic cull in treating infected areas of bronchiectasis. Failure to promptly diagnose the FBA may additionally cause complications from the utilization of non-indicated treatments, such as steroids, antibiotics, or bronchodilators (61,62).

Prevention

As a general rule, primary passive intervention strategies to reduce the jeopardy of FBA (e.g., legislation that eliminates choking hazards from the market) are more efficacious than active intervention strategies (strategies that require constant parental supervision) (63).

Materials and methods; experience of trauma unit in Red Cross War Memorial Children's Hospital, University of Cape Town

All data were recorded for every patient since 1991. All patients were treated according to the unit's management protocol (*Figure 2*).

Results

A total retrospective study was performed on 88,822 children who attended the trauma unit from January 1991 till December 2000. Fall from a height was the commonest trauma (n=32,766) 21%, transportation traumas (n=11,915) 13%, Burns (n=7,241) 8%, struck by objects (n=9,064) 10%, FBs (n=3,677) 4%, sharp objects (n=3,601) 4% and assault (n=3,302) 4% (*Figure 3*). Three-hundred and forty [340] patients were analysed in more detail.

Genders were similarly influenced. Ages went somewhere around 0 and 12 years, in spite of the fact that there was only one kid less than 1 year, at 2 years of age rate increased dramatically, with 25% of all cases happening (*Figure 4*).

Details of aspirated or ingested FBs

Most of them were of metallic nature (44%) or made of plastic (21%) (*Figure 5*).

Coins were the most common FB (30%), bead (8%) and pellet (7%), (*Figure 6*). Diameter was 0.1–3 cm.

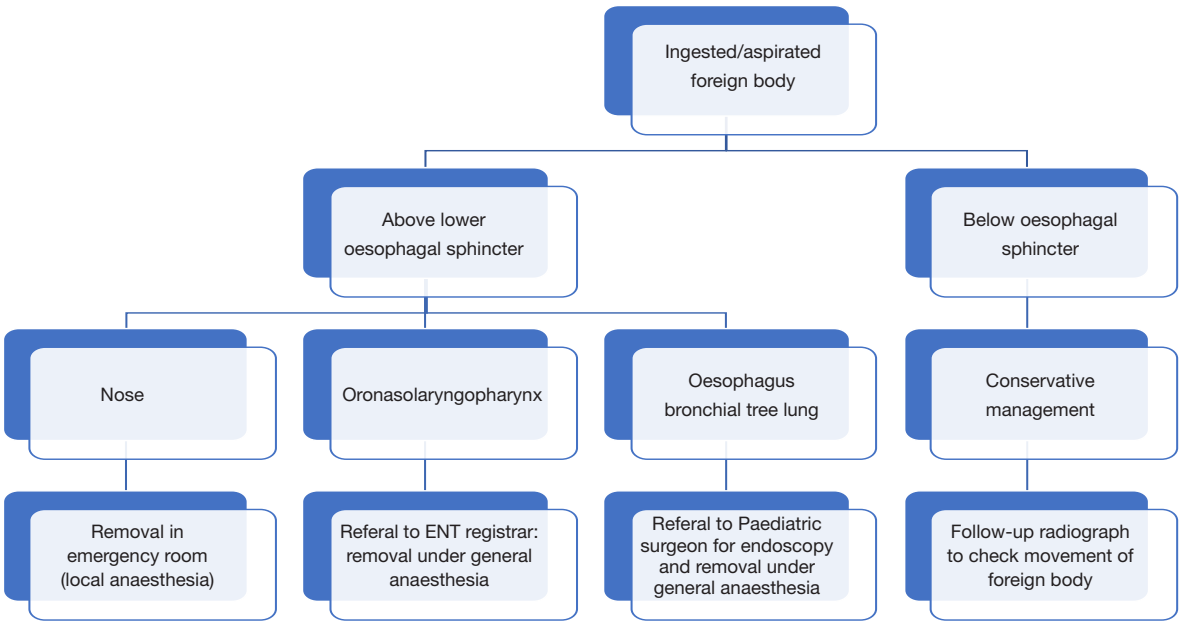

Figure 2 Management protocol of foreign bodies at the trauma unit.

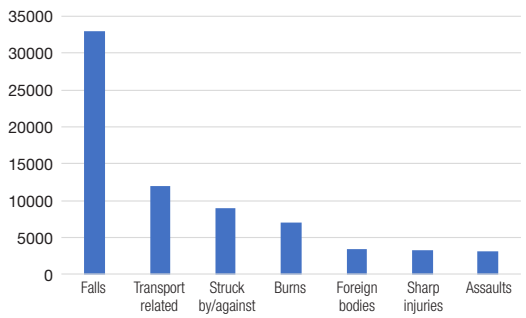

Figure 3 Number of pediatric injuries from 1991 till 2000 (n=88,822).

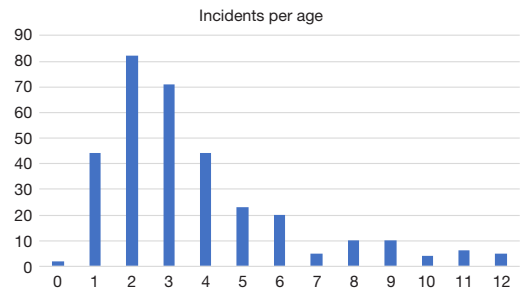

Figure 4 Number of foreign body aspiration or ingestion cases according to the ages of the children in years. FB, foreign body.

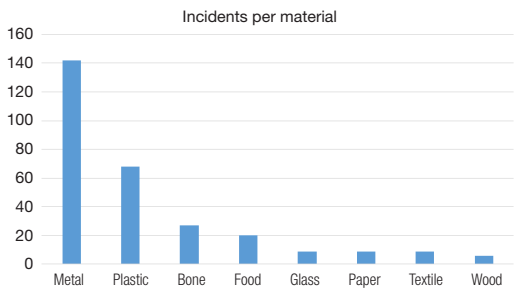

Figure 5 Material of FB. FB, foreign body.

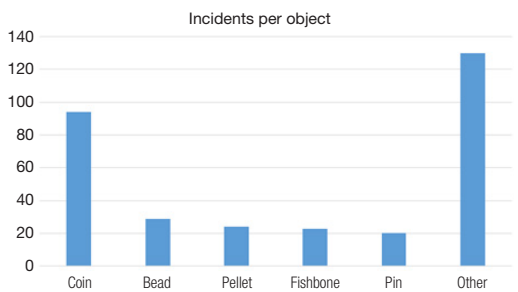

Figure 6 Ingested or aspirated foreign body: nature of the aspirated foreign body.

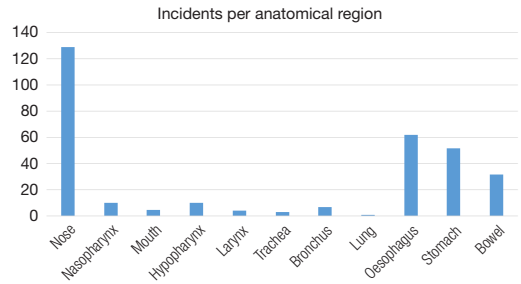

Figure 7 Ingested or aspirated foreign body: anatomical region of object.

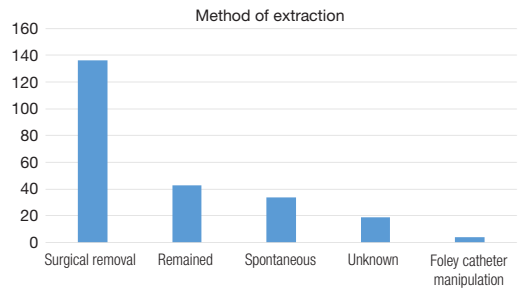

Figure 8 Method of extraction of the foreign body.

Anatomical region affected

Nose (129 cases or 41%), followed by the oesophagus (64 cases or 20%), Stomach (52 cases or 17%) and bowel (32 cases or 10%). Other anatomical sites included nasopharynx (11 cases or 4%), Hypopharynx (10 cases or 3%), bronchus (6 cases or 2%), oral cavity (4 cases or 1.3%), larynx (3 cases or 1%), trachea (2 cases or 0.7%) and lung (1 case or 0.3%) (*Figure 7*).

Severity of symptoms

Case were rated utilising the Abbreviated Injury Score (AIS). We found that 0.6% of conditions were severe, 14% were moderate and 49% were mild. Thirty six percent was asymptomatic.

Retrieval of FBs

Fifty-seven per cent (57%) of FBs were extracted by surgical means, 19% left in place, 14% spontaneously came out and 1% extracted by Foley's catheter (*Figure 8*).

Regarding the most vulnerable age for aspiration, the difference according to sex was studied. Where girls are susceptible from an early age (3.0 years), they are only at risk for a relatively brief period (3.0 to 3.9 years), a period of approximately 10 months (P=0.023). However, boys are susceptible at a later age (3.7 years), but remain at risk for a far longer duration (3.7 to 5.1 years) or a period of approximately 15 months.

Discussion

Trauma represents a very important part of mortality and morbidity worldwide with disregard to age and sex. Road traffic crashes, falls from heights and interpersonal violence are among the fundamental drivers of harm related disability and death (64).

Traditionally, trauma was viewed as unpreventable and only recently has been perceived as avoidable (65,66).

Childsafe South Africa's (CSA's) database was used as the fundamental hotspot for investigation of ingestion and aspiration trauma conditions experienced in Cape Town. Over the last 25 years we have been prospectively collecting data on all childhood injuries utilizing a constant data sheet.

There have been relatively few reports on FB ingestion and aspiration from Africa. Several reports indicate the predominance of peanuts as the aspirated FB (67,68). Where most reports indicate a low morbidity, some report a high mortality (11%) of children aspirating a FB (69). In Durban (South Africa), three children died after aspirating parts of a ballpoint pen (70).

There have been attempts to correlate the size of the ingested object with the anatomical location of impaction (71). Nearly all reports on FB ingestion show a predominance of boys (about two-thirds of all patients).

The presentation of a child with aspiration can vary greatly (e.g., in many series, less than 50% present with the history of aspiration) and the diagnosis might be difficult. However, most children present with coughing (approximately 80%), dyspnoea (approximately 70%), have abnormal auscultation (approximately 75%), or abnormal radiographs of the lateral cervical spine (soft tissue) or chest (approximately 60%).

FBs aspiration and ingestion is the fifth most common indication for admissions to our unit. In our review the rate of severe adverse outcome was very low (only 0.4%); this may be a result of transport issues in our environment. Seriously injured patients may have given up amid the long duration of transportation and we are currently gathering information on this issue.

Coins were the commonest ingested or aspirated FBs. It might be due to shortage of toys in our communities.

FBs lodged in the nose were more common than in the oesophagus. Most FBs were extracted in the operating room with the patient anaesthetized, by method for oesophagoscopy. FB's that either reached the stomach or were left alone and passed all through the GIT tract without further complications.

Although it is generally known that boys are at higher risk than girls, no detailed information is usually provided regarding prevention. An analysis was performed on the exact age for both sexes. Comparing the box and whisker diagrams of both sexes, there is a good overlap between the medians of both groups.

However, the 95% intervals calculated with the means indicate that there is a gap between the average ages of both groups susceptible for ingestion of FBs. Where girls are susceptible from an early age (3.0 years), they are only at risk for a shorter period (3.0 to 3.9 years), a period of approximately 10 months (P=0.023). However, boys are susceptible at a later age (3.7 years), but remain at risk for a far longer duration (3.7 to 5.1 years) or a period of approximately 15 months.

The results of this study confirm the frequent occurrence of FBs ingestion and aspiration in paediatrics and have implications for preventive measures. Parents of children should be educated about the specific period in which their child is most susceptible for the ingestion and aspiration of a FB, and preventive programmes should also be aimed at preschool children (e.g., minimising young children's access to metal coins).

Conclusions

Ingestion or aspiration of FBs is very common in paediatric age group. Coins were the commonest aspirated FBs in South Africa. On the premise of this study we firmly advice parents and caregivers to keep coins far from kids, particularly youngsters less than 6 years old. We used the results of this study in our programs for prevention.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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