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ORIGINAL RESEARCH

Tracheobronchial foreign body aspiration in children aged $\leq$ 2 years: the use of flexible bronchoscopy and urology stone retrieval basket in emergency setting

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Abstract

Objective: Tracheobronchial aspiration of foreign body in children is an emergency that can lead to major complications. In the last years flexible bronchoscopy has gained popularity for foreign bodies retrieval in the pediatric population, yet the small size of the pediatric airway and of the flexible bronchoscope channel limit the availability of instruments during the procedure. Aim of this paper is to describe our experience in treating foreign bodies tracheobronchial aspiration in children aged 2 years or less by means of flexible bronchoscope and an urology stone retrieval basket.

Methods: A review of endoscopic foreign bodies removal by means of flexible bronchoscopy and urology stone retrieval basket has been carried out in children $\leq$ 2 years that presented at the Emergency Room of our hospital from 2005 to 2019. In the paper, we analyze characteristics of patients, timing of bronchoscopy, instruments and operative management.

Results: There were 25 patients with a mean age of 20 $\pm$ 3.8 months. Organic material was the most frequent observed foreign body. Association of main bronchus and distal bronchi was the preferred site of the foreign body in 19 patients and the right side of the bronchial tree was involved in 17 cases. Complications occurred in one case. Mean operation time was 37 $\pm$ 20 minutes.

Conclusions: The use of flexible bronchoscope can be helpful in handling endoscopic removal of tracheobronchial foreign bodies in toddlers. The use of the urology stone retrieval basket resulted very effective in all shapes of foreign bodies and/or when the object was located in the distal bronchi.

Keywords

Foreign body; Aspiration; Bronchoscopy; Children

1. Introduction

Foreign body (FB) aspiration occurs in children less than 3 years old with prevalence of males in 75.4% of the total cases of aspirations [1]. Mortality in large series reached to 1.8% and, in 2005, FBs aspiration was the fourth leading cause of accidental mortality in children [2–4]. Rigid bronchoscopy has always been considered the modality of choice in extracting FBs [5–8] however, distal location of the objects and the small size of the patient's airways might decrease the success rate of FB extraction in children.

Flexible bronchoscopy raised his popularity in the last years [9–11] due to the increasing availability of proper instruments and the possibility to explore the distal tracheobronchial tree [9, 10]. A combination of the two techniques is also advocated by some Authors [6, 12].

Despite the advantages of the flexible bronchoscopy, it is often difficult to remove FBs in toddlers with this technique, due to the limited selections of grasping tools capable of passing through the 1.2 mm instrument channel of the ultrathin bronchoscope [1, 13, 14]. We describe removal of tracheobronchial FB by means of flexible bronchoscope and the urology stone retrieval basket in children aged two years or less. In this series, we analyze characteristics of patients, timing of flexible bronchoscopy, instruments and operative management.

2. Materials and methods

We included in this report 25 children aged 2 years or less, presented at the Emergency Room with evidence of FB's aspiration and treated with flexible bronchoscopy and the urology retrieval stone basket. Patients selection took place among 110 children aged from 20 months to 18 years that, from 2005 to 2019, underwent a bronchoscopy for suspected FB aspiration at our Department of Thoracic Surgery.

Upon the arrival at the Hospital, parents were questioned about the alleged timing and kind of aspiration and the oper-

ative room was alerted. Preoperative workout included only EKG and blood tests. Radiological exams in these cases were not necessary.

Flexible bronchoscopy was chosen in these series instead of rigid bronchoscopy in order to be able to easily reach the distal bronchi with the instrument considering the small size of the patients' airway. Although rigid bronchoscope or combination with flexible bronchoscope is routinely used in our Department for adults and children, in these cases we preferred the combination of flexible bronchoscopy and endotracheal tube to minimize the intubation trauma considering the possible need to reenter the airway more than one time as in the case of the FB having to be extracted together with the bronchoscope due to its size.

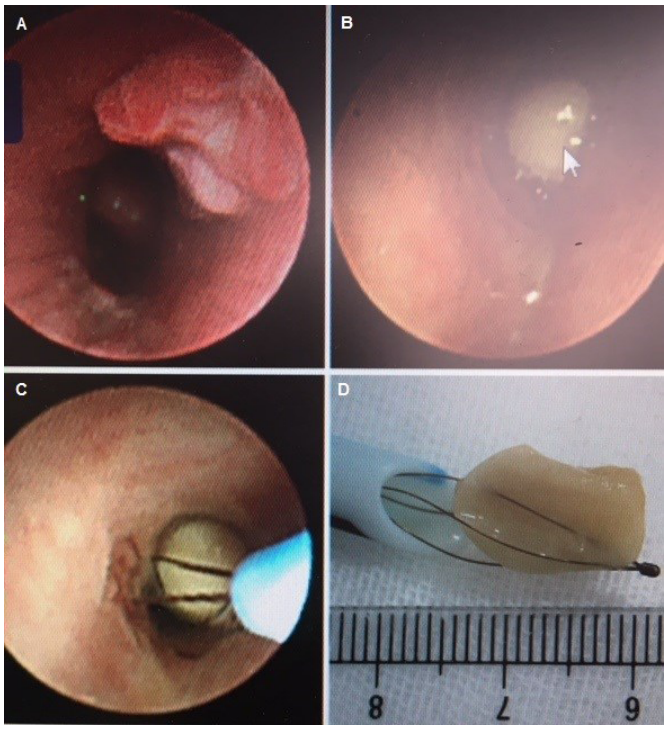

FIGURE 1. A: endoscopic view of inflammatory response of the bronchial mucosa; B: fruit seed occupying the bronchus; C: Zero Tip Nitinol Stone retrieval Basket; D: The retrieval basket extracted contextually with the endotracheal tube.

As described before [15], all bronchoscopies were performed in the operative room by two thoracic surgeons under general anesthesia with fentanyl, propofol and cisatracurium. Topic 2% lidocaine without vasoconstrictor was used as an anesthetic of the larynx, trachea and bronchi. A direct laryngoscopy was performed before intubation. During the procedure, patients were monitored with oximetry, cardiac monitor, and noninvasive arterial pressure measurements. The ultrathin flexible bronchoscope (Pentax FB8V 2.8 mm) was introduced through the single-lumen tube. After the explorative bronchoscopy, the exact location of the FB was visualized and the retrieval basket (Zero Tip Nitinol Stone Retrieval Basket, Boston Scientific 1.9 Fr, 0.63 mm × 120 cm) (Fig. 1C) was inserted through the 1.2 mm channel of the scope having cure not to push the basket too distally in the airway. The FB was securely grasped from beside and the basket was gently retracted toward the tip of the bronchoscope. The bronchoscope was then extracted through the endotracheal tube. When the diameter of the FB occupied the trachea or a main bronchus, the bronchoscope and the basket were retracted en bloc into the single-lumen tube and the patient was extubated in order to avoid the rupture of the device into the bronchial tree (Fig. 1D).

When a strong inflammatory process avoided the removal of the FB, a second procedure was performed after a week of systemic corticosteroid and antibiotic therapy (Fig. 1A).

A final exploration of the tracheobronchial tree was performed at the end of the procedure to ensure the complete removal of all FBs. Patients were extubated in the operative room and in absence of complications were discharged on postoperative day first.

3. Results

Features of the patients are reported in Table 1. There were 22 males and three females with a mean age of 20 ± 3.8 months (range 11-24 months) and a mean weight of 13.9 ± 2.7 kg (range 10-19.3 kg). The elapsed time between the aspiration and the endoscopic procedure varied from 0 to 48 days (mean 5.8 ± 9.7 days). All patients underwent bronchoscopy within few hours from the arrival at the Emergency Room.

The most frequent inhaled material was organic, including peanuts in 11 cases, a piece of plastic toy in five cases, fruit seed in three cases (Fig. 1B) and chestnut skin in 1. The right bronchial tree was the preferred site of FB's location in 17 patients, both localization in the main bronchus and distal bronchi happened in 5 cases (patients 1, 2, 3, 6, and 10). Two patients underwent two bronchoscopies in seven days due to the strong inflammatory reaction around the FB that jeopardized its removal on a first attempt (patients 3 and 6). Mean operative time was 37 ± 20 minutes (range 20-120 minutes). Patients undergoing a second procedure required a longer operative time due also to different attempts of FB's removal with different grasping forceps.

Complications occurred only in patient number 3 and consisted of post extubation bronchospasms controlled with medical therapy. The longest interval between FB's aspiration and its removal was correlated with the onset of postoperative complication in patient number 3.

4. Discussion

Bronchoscopic removal of FBs is a delicate procedure with a high potential risk for complications such as migration of the object, hypoxia, bradycardia and bronchospasms that can lead the patient to death [4, 6]. Aspiration of FBs shows a bimodal occurrence with one peak in children aged less than three years [4, 16].

Rigid bronchoscopy has always been advocated as the main choice for tracheobronchial FB removal [5, 6] considering the possibility to provide adequate ventilation during the procedure and the variety of available instruments that can be inserted into the scope. However, extraction of FB is sometimes difficult because of fragmentation and migration of the object while the flexible bronchoscopy easily allows exploration of

TABLE 1. Characteristics of the patients and intraoperative data.

Case n°	Sex	Age (months)	Weight (Kg)	Procedures n°	Site	Foreign body	Days from aspiration	Operation time (tot min)	ET tube size
1	M	22	15.0	1	Trachea + RMB + DB	Peanut	1	35	6
2	M	15	10.0	1	RMB + DB	Peanut	13	35	4
3	M	18	11.8	2	IB + DB	Plastic	48	120	5.5
4	M	24	11.3	1	LMB	Seed	15	40	5
5	F	15	10.5	1	RULB	Peanut	10	55	4
6	M	24	11.3	2	RMB + DB	Peanut	7	70	5.5
7	M	11	10.0	1	RMB	Chestnut skin	1	20	4.5
8	M	23	13	1	IB	Peanut	2	25	6
9	M	18	12.4	1	RMB	Plastic	11	35	5.5
10	F	22	13.2	1	LMB + DB	Peanut	3	20	6.0
11	M	13	12.3	1	RMB	Peanut	1	27	5.5
12	M	18	13.4	1	RULB	Seed	1	25	6
13	M	23	15.6	1	IB	Plastic	0	30	6
14	M	24	13.2	1	RMB	Peanut	1	38	6
15	M	21	11.8	1	RMB + DB	Pea	3	42	5.5
16	M	19	17	1	LMB	Pebble	1	28	6
17	M	18	14.7	1	Trachea + LMB	Plastic	0	20	6
18	F	22	16.8	1	RMB	Peanut	1	22	6
19	M	24	18.3	1	RULB	Seed	1	28	6
20	M	22	17.3	1	LUB	Pea	1	32	6
21	M	21	16.2	1	LLB	Pebble	2	40	6
22	M	14	11.2	1	RMB	Pea	1	31	5
23	M	23	17.4	1	LMB + DB	Peanut	1	30	6
24	M	24	19.3	1	RMB	Plastic	1	38	5
25	M	23	16.7	1	LLB	Peanut	1	42	5

Legend: RMB = right main bronchus; RULB = right upper lobe bronchus; IB = intermediate bronchus; LMB = left main bronchus; LUB = left upper bronchus; LLB = left lower bronchus; DB = distal bronchi.

the distal bronchi. Moreover, in case of repeated procedures, the rigid bronchoscope might cause swelling of the vocal cords and laryngeal edema. Despite the difference among Centers, there are no studies comparing the two methods in FB aspiration management [9, 10].

Limitation of the pediatric flexible bronchoscope might be the small size of the working channel and the paucity of available grasping instruments [9]. Some Authors prefer the association of rigid and flexible bronchoscopy to combine an adequate control of the airway and the possibility to explore the distal bronchi [2, 17]. In selected cases, fluoroscopy was added to the procedure to reach the peripheral bronchi [18]. In our experience, the possibility of repeated intubation in the same procedure led us to prefer the combination of endotracheal tube and flexible bronchoscope in this series of small patients.

We have found that flexible bronchoscopy performed in general anesthesia with muscle paralysis allows patient's safety and avoids possible injuries to the vocal cords during the passage of the FB. Flexible bronchoscopy through endobronchial tube is our preferred choice in children aged less than three years old when FB aspiration is likely to have occurred more than 48 hours before. This is due to the fact that a strong inflammatory reaction in the bronchi might lead to the necessity of repeated procedures and though repeated intubations. We prefer the ultrathin 2.8 mm scope versus the 3.5 mm one, because it allows to support an adequate ventilatory space into the endotracheal tube.

Most of the inhaled FBs in children aged three years or less are organic [12]. Their fragility and shape, associated with a slippery surface makes the use of grasping forceps difficult. We experienced this difficulty too; in our series, patient number 3, presented a strong inflammatory response around the FB, and the second procedure lasted a long time because we made different attempts with grasping forceps before switching to the retrieval basket.

Different technique, mostly limited to case reports, are present in the literature, describing usefulness of urology basket [1, 5, 13, 19] endobronchial Roth-Net [20] and Fogarty catheter [14]. The use of forceps of various shapes, baskets, snaring wire, coagulation knives, and probes for

cryotherapy is also reported [21]. In pediatric patients, the available instruments are particularly limited, due to the thinner instrument channel of bronchoscopes. The pediatric expandable basket Roth-Net [20] diameter is 1.8 mm requiring a minimum scope channel of 2.0 mm. The pediatric flexible bronchoscopes in our current equipment are Pentax FB8V 2.8 mm and Pentax FB10V 3.5 mm, but despite the different outer diameter, both have a working channel of 1.2 mm, thus limiting the use of several tools. An instrument adaptable to the small channel of the pediatric flexible bronchoscope could be a basket known for Wharton's duct stones removal [22] but we have no experience in this regard.

We have used a stone retrieval basket designed for use in the kidney and ureter (Nitinol stone retrieval basket, diameter 0.63 mm) that could be inserted through the 1.2 mm working channel of the pediatric scope. This tipless basket, differently from the Dormia basket, allows close FB approximation in the tracheobronchial tree. The flat distal surface eliminates tissue-to-tip interface giving an atraumatic manipulation and the knotted wires give stability to the basket to hold firmly the FB during the extraction. However it is important not to push the device too distally in order to prevent perforation of the bronchi that might easily occur in infants [23]. Moreover, the small size of the basket allows his allocation in the peripheral bronchi that in our series were the site of the FB in four patients. In case 1 the trachea and the main right bronchus were completely occluded by peanut fragments and giving the small size of the basket we were able to pass the obstruction and to retrieve all the fragments that were allocated through all the distal right lower bronchi.

Although flexible bronchoscopy can be considered as a valid option for FB retrieval, rigid bronchoscopy should be always available in the operative room and the surgical team should be qualified and ready to switch to any surgical option such as tracheostomy and/or bronchotomy [24].

In our Institute all interventional bronchoscopies are performed by thoracic surgeons and, therefore, any complication are handled by the same team.

Type of anesthesia is an issue of controversy with different Centers choosing spontaneous ventilation through laryngeal mask [11, 13]. We agree with Authors that report that general anesthesia with muscle paralysis seems to provide a better control of the ventilation and to decrease life-threatening complications in children aged less than four years [25–27]. Moreover, it is possible to safely switch to surgical procedure.

Limitations of this series might be due to the small number of cases reported and the absence of a comparison with a series treated by means of a different technique. It would be also interesting to compare the data of the procedures performed in rigid and flexible bronchoscopy in terms of duration of the procedure, complication and results.

5. Conclusions

We conclude that flexible bronchoscopy for FB retrieval in patients aged two years or less, in expert hands, could be a safe procedure. Generalized anesthesia with muscle paralysis gives the chance to have a better control of the patient and the possibility to switch quickly to surgical procedures. The use of an ultrathin bronchoscope through the endotracheal tube allows more space ventilation. The combination with the tip less urology stone retrieval basket can be helpful in increasing the percentage of success reducing the risk of tracheobronchial tree trauma.

AUTHOR CONTRIBUTIONS

PC is responsible for the conception and the writing of the study and had full access to all of the data with PM; she takes responsibility for the integrity of the data and the accuracy of the data analysis. AC, PM, and GN contributed substantially to the study design, data analysis and interpretation. All authors contributed and have approved the final article.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Informed consent for the procedure and data usage was obtained by both children parents. The ethics committee of Hospital San Raffaele waived the need for approval.

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CONFLICT OF INTEREST

The Authors declare no competing interests.

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