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Research article

Factors associated with complications of foreign body ingestion and/or aspiration in children from a Peruvian hospital

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ABSTRACT

Objective: To determine the factors associated with complications of foreign body ingestion and/or aspiration in children from a hospital in the Peruvian social security program.
Materials and methods: An observational, retrospective, analytical, and transverse study was undertaken. Medical records of patients under the age of 14 years old, who were admitted to the National Hospital Edgardo Rebagliati Martins between January 2013 and May 2017, and treated with a diagnosis of foreign body in the digestive or respiratory tract, were selected. Variables that characterized the foreign body ingestion and/or aspiration were assessed. STATA v11.1 was used for all subsequent statistical analyzes.
Results: A total of 322 cases met the inclusion criteria and the median age of the cohort was 4 years old (interquartile range: 2–6). The most frequently ingested foreign bodies were coins (~59%) and batteries (~10%). Fifty-four cases (~17%) were classed as having a complication. In the multivariate analysis, we observed that the frequency of complications increased when the ingested object was a battery (adjusted prevalence ratio (aPR): 2.89; 95% confidence interval (CI): 2.52–3.32; p-value<0.001), when the time elapsed prior to diagnosis was 8–16 h (aPR: 2.23; 95% CI: 2.18–2.28; p-value<0.001), and when the child was male (aPR: 1.85; 95% CI: 1.24–2.74; p-value = 0.002). However, the frequency decreased in cases where foreign bodies were lodged in the nose (aPR: 0.97; 95% CI: 0.97–0.98; p-value<0.001).
Conclusions: Whilst the most frequently ingested foreign bodies in this study were coins, complications were more common in cases of battery ingestion and in those where the diagnosis was made after 8 h.

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1. Introduction

Ingestion and/or aspiration of foreign bodies are occurrences that typically affect the pediatric population, mainly children under the age of 4 years old [1,2]. In the United States, over 100,000 cases are reported annually, the majority of which are accidental events [3–5].

In cases of foreign body *ingestion*, complications are generally uncommon and are primarily dependent on the passage of the foreign body through areas of anatomical narrowing in the esophagus [3,5]. However, the same is not true for cases of foreign body *aspiration*, which can quickly lead to life-threatening airway emergencies. Indeed, in the United States, these aspirations are responsible for approximately 300–600 deaths annually in children under the age of 15 years old. Therefore, in the latter case, the principles of both early detection of foreign bodies and prompt management have been strongly emphasized [6–8].

The complications elicited from foreign body ingestion and/or aspiration reflect the type of object in question, its anatomical location, and the time since the incident occurred [2,8–11]. In clinical settings, several invasive methods are available to try to avoid complications. For instance, in cases of foreign body ingestion, both upper digestive tract endoscopy [5] and the Foley catheter method can be used [12]. On the other hand, in cases of foreign body aspiration, management depends mainly on the clinical situation, given the risk of airway emergencies. If the patient is stable, it may be possible to utilize bronchoscopy [13] or a Magill forceps [2].

Although there is published literature on this important clinical topic, high-quality statistical data describing the Peruvian pediatric population remains scarce. Further, geographical and societal populations may vary in terms of frequencies of presentation and factors associated with related complications. Therefore, we aimed to determine the factors associated with foreign body ingestion and/or aspiration, as well as their complications, in children from a hospital in the Peruvian social security program.

2. Materials and methods

We conducted an observational, retrospective, analytical, and transverse study. We reviewed the medical records of all patients under the age of 14 years old, who were admitted to the National Hospital Edgardo Rebagliati Martins and treated with a diagnosis of foreign body in the digestive or respiratory tract. The included patients were those who presented with foreign body ingestion and/or aspiration to the pediatric emergency service of the hospital between January 2013 to May 2017. Children who presented with a foreign body due to physical abuse were excluded (less than 0.5% of the initially included study population).

The main variable of interest in this study was whether the foreign body ingestion and/or aspiration caused the patient any direct complications. Variables that characterized foreign body ingestion and/or aspiration were assessed, including the: affected tract (respiratory or digestive); location in the respiratory tract (nose, pharynx, trachea, or bronchus) or digestive tract (esophagus, stomach, or intestine); type of foreign body (coin, battery, plastic, bone, or other); shape of the foreign body (blunt/smooth, sharp-cutting, or other); size of the foreign body ($<$ or $\geq$2 cm); composition of the foreign body (organic or inorganic); time to diagnosis ($<$8, 8–16, or $>$16 h); need for endoscopy; and gender and age of the child. In addition, the time taken for admission to the emergency unit, review by a gastroenterologist, and completion of an endoscopy were also recorded in our review of the medical records. None of the cases included in the study were serious, that is, without risk to the lives of patients. However, although there were no cases requiring admission to the intensive care unit, procedures to extract foreign bodies were needed.

Prior to beginning the study, approval was requested and obtained from the Training, Research and Teaching Office of the National Hospital Edgardo Rebagliati Martins under the number 170212-CIEI/HONADOMANI.SB (the need for informed patient consent was waived, since there was no direct contact with patients or any impact on their treatment). Patient confidentiality and anonymity of data was maintained at all times. We consulted medical records to access the data of patients with a diagnosis of foreign body ingestion and/or aspiration (who were treated during the aforementioned time period), in accordance with the inclusion criteria. The obtained data was entered into and stored on a secure Microsoft Excel spreadsheet (v2013 for Windows).

STATA v11.1 was used for all statistical analyzes (Stata Corp., College Station, TX, USA). Frequencies and percentages were estimated for all categorical variables, while quantitative variables were represented as the median with interquartile range (in accordance with the results of normal distribution testing).

Further, a bivariate analysis was undertaken. We used the chi-square test, where a p-value < 0.05 was considered to be statistically significant. Subsequently, we performed a multivariate analysis to obtain both the raw prevalence ratio (rPR) and adjusted prevalence ratio (aPR), with 95% confidence intervals (CI). For this, generalized linear model tests were run with a Poisson distribution (which determines the prevalence ratio) and robust models to estimate errors (which allow for adjusting of results according to the sample size).

The statistical power was calculated to determine if the sample size was sufficient to allow for comparison with the evaluated characteristics. We observed that in almost all cases, the statistical power exceeded 80%, thereby providing confidence when interpreting the results. The values for only two variables did not exceed this threshold, the size of the foreign body (52%) and the need for an endoscopy (26%), so only these two cases were based on exploratory analyzes.

For the purpose of this study, the term ‘complication’ was defined as a serious disorder resulting from the foreign body ingestion and/or aspiration that affected the health of the child, for example: cardio-respiratory distress or shock; digestive and/or respiratory tract burn; perforation; and mediastinitis.

3. Results

A total of 322 cases met the inclusion criteria, of which 188 (58.4%) were male patients. The median age of the cohort was 4 years

old (interquartile range: 2–6), and the majority of patients were referred from another hospital in the region (91.3%). When considering the characteristics of the ingestion/aspiration, our results revealed that cases were more likely to lead to complications when a battery was ingested (56.3%), when the object was organic (44.1%), when the diagnosis was made between 8 and 16 h (47.1%), and when there was a significant time delay until the completion of an endoscopy (median time: 397 min) (Table 1).

In our cohort, 54 (~17%) patients had complications. In cases of foreign body aspiration, the location with the highest frequency of complications was nasal aspiration (80%, p-value = 0.006) (Fig. 1A). However, in cases of foreign body ingestion, the frequency of complications was less predictable and ranged between 15 and 27% (p-value = 0.354), depending on the location of the object in the digestive tract (Fig. 1B).

In the multivariate analysis, we demonstrated that the frequency of complications increased when: the ingested object was a battery (aPR: 2.89; 95% CI: 2.52–3.32; p-value<0.001); the time elapsed until the diagnosis was 8–16 h (aPR: 2.23; 95% CI: 2.18–2.28; p-value<0.001); and when the child was male (aPR: 1.85; 95% CI: 1.24–2.74; p-value = 0.002). However, the frequency decreased in cases where foreign bodies were lodged in the nose (aPR: 0.97; 95% CI: 0.97–0.98; p-value<0.001). These differences were adjusted to account for the type of material, size of the foreign body, and affected tract (respiratory/digestive) (Table 2).

4. Discussion

In this study, 1 in 6 patients (~17%) developed some form of complication due to foreign body ingestion. This result is of public health importance, given that foreign body injuries represent a serious healthcare burden in children, especially in infancy [14]. The nature of children, who evaluate objects by tasting and swallowing them [15] and without an awareness of the dangers and complications that may be caused, is often the causative factor in these incidents.

Previous studies have reported the frequencies of complications due to foreign body ingestions in children around 20% [16,17], which corroborate our study's findings. Results from these studies also showed that over 90% of cases of esophageal foreign bodies resolve spontaneously and without medical removal, whilst 10% may remain in the gastrointestinal tract. Further, it is estimated that 10–20% of foreign bodies in the gastrointestinal tract of children require endoscopic intervention for their removal, and that ~1% require open surgery secondary to associated complications [17]. Therefore, it is important that our results are further evaluated in other pediatric populations, since ingestion and/or aspiration of foreign bodies represents a potentially life-threatening presentation. However, much of the risk is preventable via parental and teacher education and awareness. In an important Spanish study the authors recommend that the existence of legislation and information on product labels that define the minimum age for their use, as well as

Table 1
Characteristics of foreign body ingestion and/or aspiration and their association with complications (as defined in Materials and Methods).

Variable	Complications*		p-value
	Yes	No	
Compromised area			
Respiratory tract	4 (33.3)	8 (66.7)	0.144
Gastrointestinal tract	50 (17.0)	245 (83.0)	
Type of object			
Coin	24 (12.5)	168 (87.5)	<0.001
Battery	18 (56.3)	14 (43.7)	
Plastic	4 (26.7)	11 (73.3)	
Bone	3 (15.0)	17 (85.0)	
Other	4 (12.9)	27 (87.1)	
Object shape			
Blunt/smooth	50 (18.3)	223 (81.7)	0.554
Sharp-cutting	3 (15.8)	16 (84.2)	
Other	0 (0.0)	5 (100.0)	
Object size			
More than 2 cm	7 (12.1)	51 (87.9)	0.241
Less than 2 cm	35 (18.7)	152 (81.3)	
Object composition			
Organic	15 (44.1)	19 (55.9)	<0.001
Inorganic	39 (14.8)	225 (85.2)	
Time elapsed until diagnosis			
Less than 8 h	32 (14.4)	191 (85.6)	0.002
8–16 h	8 (47.1)	9 (52.9)	
More than 16 h	1 (9.1)	10 (90.9)	
Required endoscopy			
Yes	31 (17.1)	150 (82.9)	0.407
No	9 (12.9)	61 (87.1)	
Minutes until**			
Being attended in emergency rooms	6.5 (4–15)	8 (5–12)	0.784
Assessment by a gastroenterologist	233 (137–258)	240 (167–451)	0.055
Endoscopy	397 (361–488)	525 (403–775)	0.037

* Categorical variables are represented as n (%).
** Descriptive values are represented as median (interquartile range).

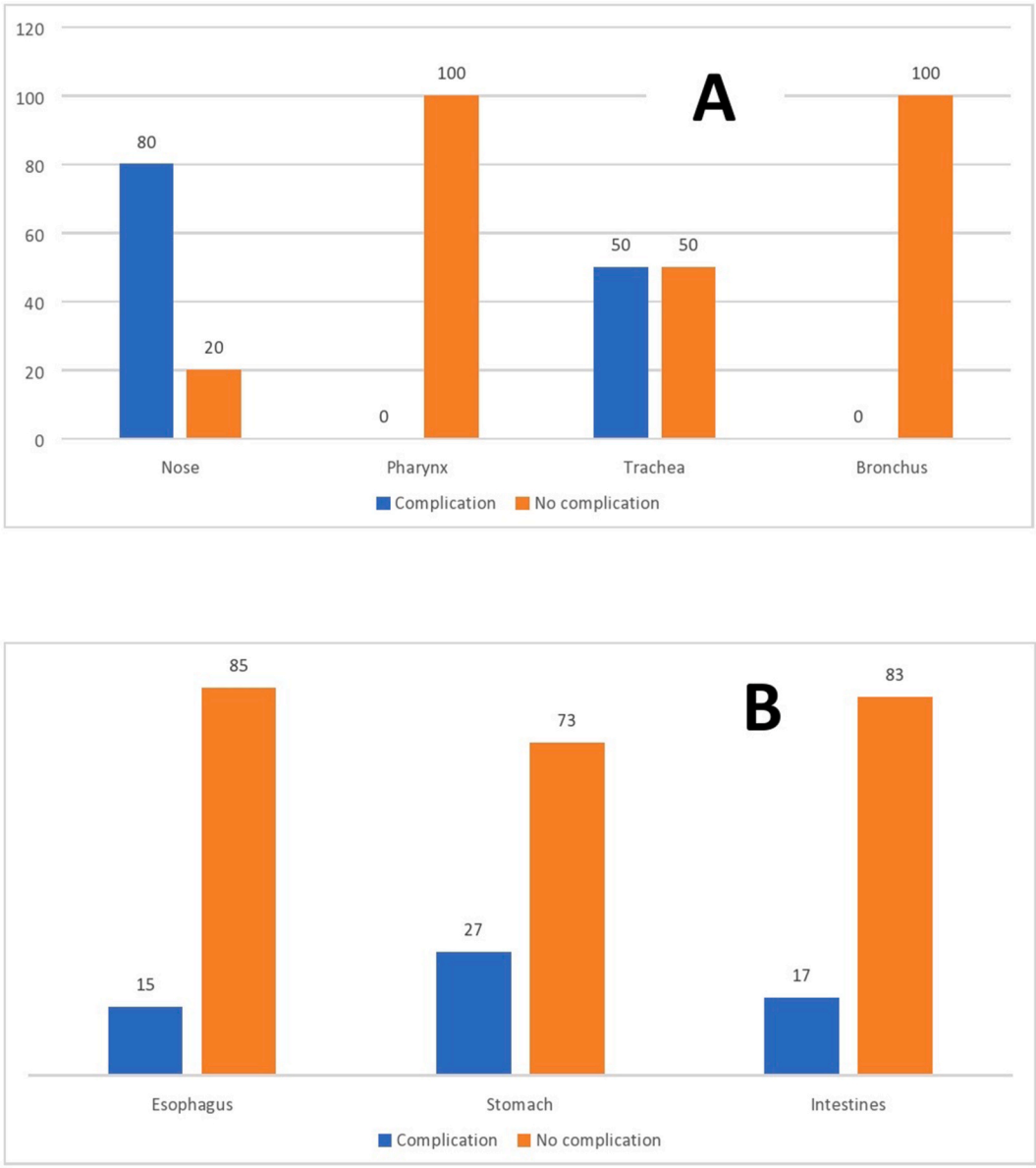

Fig. 1. Percentage of complications in the respiratory (A) and gastrointestinal (B) tracts, categorized by anatomical location, subsequent to foreign body ingestion and/or aspiration.

education and awareness of parents, teachers and the general population are essential in this context [18].

According to our results, batteries were the second most frequently ingested objects after coins, accounting for ~1 in every 10 cases, but had the highest rate of complications (56.3%). Recent studies have reported an increase in the prevalence and rate of complications associated with battery ingestion [8,19,20]. This is likely due to the recent increase in demand for home appliances and electronic toys, most of which are battery-operated [21]. Moreover, the use of batteries with a diameter of over 2 cm or larger is associated with an increased number of complications following ingestions [17,20]. Therefore, although our study did not assess the appliances from which the children obtained the batteries, appropriate safety measures should be taken for monitoring and prevention of their ingestion. Given that serious complications of battery ingestion have been previously reported in the literature including trache-oesophageal fistulas (~48%), esophageal perforations (~23%), esophageal strictures or stenosis requiring repeated dilations (~38%), and vocal cord paralysis from recurrent laryngeal nerve damage (~10%), the risk of mortality with this presentation should not be discounted [20]. If, on the one hand, in our study cohort we did not observe any cases of death, a larger series of patients with battery ingestion could possibly lead to this outcome [22].

Another key factor associated with complications in our cohort was the time elapsed until the diagnosis was made. Our findings indicate that the frequency of complications is increased in cases where the diagnosis is only made 8–16 h after the fact. This finding is

Table 2
Results of a multivariate analysis of factors related to complications after foreign body ingestion and/or aspiration.

Variable	rPR (95% CI)	p-value	aPR (95% CI)	p-value
Foreign body lodged in the nose	4.83 (4.36–5.36)	<0.001	0.97 (0.97–0.98)	<0.001
Battery	4.02 (3.66–4.41)	<0.001	2.89 (2.52–3.32)	<0.001
8–16 h until the diagnosis	3.34 (2.49–4.47)	<0.001	2.23 (2.18–2.28)	<0.001
Organic material	2.90 (2.34–3.59)	<0.001	0.66 (0.02–26.4)	0.826
Object size < 2 cm	1.55 (1.10–2.19)	0.013	1.03 (0.78–1.35)	0.842
Male sex	1.49 (1.13–1.96)	0.005	1.85 (1.24–2.74)	0.002
Minutes until*				
Being attended in emergency rooms**	1.02 (1.01–1.03)	0.002	–	
Assessment by a gastroenterologist**	0.99 (0.99–0.99)	0.002	–	
Endoscopy**	0.99 (0.99–0.99)	0.031	–	
Age (years)*	0.99 (0.97–1.02)	0.644	–	
Required endoscopy	1.35 (0.99–1.86)	0.059	–	

rPR = raw prevalence ratio; aPR = adjusted prevalence ratio; 95% CI = 95% confidence intervals.
* Quantitative variables.
** These variables were not included in the final analysis model due to lack of obtained data.

in line with previous studies, which have shown that a longer time period between ingestion of a foreign body and referral to a health care center for assessment and management may be associated with a greater risk of complications [14]. This could be explained by noting that time lags until diagnosis may allow for the development of pathophysiological complications. For example, in cases of battery ingestion, there is generation of an external electrolytic current that hydrolyzes tissue fluid and produces hydroxide at the negative pole of the battery, resulting in leakage of alkaline electrolyte contents (hydroxide) alongside the physical pressure on adjacent tissues [20,23]. As such, swift patient evaluation by an expert team is essential, since the medical processes of care, diagnosis, and treatment requires a coordinated and multidisciplinary approach. Therefore, the implementation of effective measures to fast track proper diagnosis in urgent cases should be ensured when planning health services provision.

When considering gender associations, we found that male children had greater complication rates than female children. This could be explained by the higher frequency of foreign body ingestion by males, therefore presenting a greater risk for developing complications.

It is also worth noting that this study reported a lower complication rate in cases of a foreign body in the nose, when compared to other variables in the multivariate analysis. Previous investigations surrounding foreign body ingestion and/or aspiration have shown high rates of successful removal of foreign bodies from this location [24,25], as when a foreign body is introduced into one of the nostrils, the child can still breathe through the other nostril and their mouth. Further, we can deduce that the removal of foreign bodies from the nose is generally more straightforward than in other regions, as in many cases the removal can be achieved simply by instructing the child to exhale forcefully through only the nose.

Regarding limitations, this study has the potential limitation of information bias. Since the data was not analyzed in accordance with its initial purpose, we could not obtain further relevant data, which may have aided in characterizing complications and other related factors in more detail. A further potential limitation is the difficulty in extrapolating our data to a larger or international population. Despite these limitations, our results are of great importance, given that a representative sample population of children was evaluated over a long time, which makes this study the first of its kind in this region of Peru. Therefore, we believe that the findings can and should serve as a reference for future research efforts globally.

In conclusion, this study demonstrated that ~1 in 6 pediatric patients developed some form of complication subsequent to a foreign body ingestion and/or aspiration. The frequency of complications was higher in cases of battery ingestion and in those whose diagnosis was made after 8 h. In light of this data, it is always important to remember that children are innately curious and have a tendency to put objects they find in their mouth or nose. Hence, it is important to eliminate potential hazards, especially those related to small objects that can be easily detached by children or which are within their reach. These simple measures may well prevent hospital admission and threats to life from complications of ingestion and/or aspiration of foreign bodies.

Author contribution statement

Brian M. Romero; Christian R. Mejia: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Stephany Vilchez-Bravo; Gustavo Hernández-Arriaga; Lotty Bueso-Pineda; Thomas Franchi: Analyzed and interpreted the data; Wrote the paper.

Marcos Roberto Tovani-Palone: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of interest's statement

The authors declare the following conflict of interests: The authors declare no conflicts of interest. Marcos Roberto Tovani-Palone is one of the section editors of Heliyon, however the article will not be assigned to him or any of his colleagues.

Abbreviations

rPR	raw prevalence ratio
aPR	adjusted prevalence ratio
CI	confidence intervals

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