Symptoms associated with button batteries injuries in children: An epidemiological review

Symptoms associated with button batteries injuries in children: An epidemiological review

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Abstract

Objectives: To provide an epidemiological framework of symptoms related to Foreign Body (FB) injuries due to Button Battery (BB).

Methods: Data on BB ingestion/inhalation have been obtained from the ButtonBatteryDB. The ButtonBatteryDB is a database collecting information on BB injuries in children (0–18 years of age). Data on 348 BB injures have been derived from the Registry of Foreign Body Injuries ‘‘Susy Safe’’ (269 cases) and from published scientific literature reporting case reports of FB injuries (79 cases).

Results: Most of injured children were male and BBs were found more often in the mouth/esophagus/ stomach (ICD935) and in the nose (ICD932). Analyzing symptoms related to BB located in the esophagus/ mouth/stomach, we found that children had higher probability of experiencing dysphagia (30.19%, 95% C.I. 17.83–42.55), fever and cough (26.42%, 95% C.I. 14.55–38.28), compared to the other symptoms. Referring to the probability that symptoms occurred simultaneously, fever and cough are more likely (3.72%, 95% C.I. 1.0–6-43) to jointly showing up in children with BB in mouth/esophagus/stomach (ICD935), followed by fever and dysphagia (2.66%, 95% C.I. 0.36–4.96) and by fever and irritability/crying, fever and drooling, dysphagia and irritability/crying (2.13% C.I. 0.00–4.19, 95% C.I.)

Conclusions: These findings provide new insight in clinical presentation of BB injuries: the identification of unique patterns of symptoms related to BB injuries is useful to perform an early diagnosis (and to guarantee a prompt medical reaction), also when the injury is un-witnessed.

1. Introduction

Foreign Bodies (FB) injuries are common in pediatric age, especially in children aged 0–3 years. The higher prevalence of FB injuries in young children is related to physiological characteristics of preschoolers: they explore objects using the mouth and are unable to distinguish edible from non-edible objects. Additionally, young children still have a poor coordination between chewing and swallowing and their teeth are physiologically lacking, determining difficulties in crumbling the food with a consequently high risk of aspirating food’s fragments [1].

Referring to object types ingested/inhaled by children, it has been demonstrated that most of FB injuries are due to inorganic objects [2]. Button Batteries (BBs) represent a specific type of inorganic object due to the severe complications they could lead to [3].

Literature reports only 6 cases of BB ingestion before 1983 (the first one was reported in 1977) [4]. Noticeably, the incidence of these types of injuries has been rapidly increased in the last decades, with 66,000 estimated access due to BB injuries (in children younger than 18 years of age) in the US Emergency Departments from 1990 to 2009 [5]. The dramatic rise in the prevalence of BB injuries is mainly related to: (i) the increased number of toys (and other kind of devices, e.g., watches) using these types of batteries, (ii) the shape of the battery which could be attractive for young children because they may get confused with other food-like objects, like candies and (iii) the fact that, the battery, well after ingestion, it still contains enough power to cause injuries.

Complications due to BB injuries could be related to the release of the toxic content of the battery, which could determine both tissues' damages and systemic poisoning (metal toxicity) due to potential systemic absorption of battery's degradation substances. However, the mechanism most frequently described to be related to BB injuries' complications is represented by the generation of an electronic current from the battery in contact with tissue fluids [6]. This reaction determines the production of a substance, the hydroxide, which is dangerous and could lead to severe complications: necrosis, perforation, fistula, hemorrhage and even death [7–9].

The occurrence of complications due to BB injuries is related both to the characteristics of the child injured by the BB and of the BB itself. More specifically, the ingestion of a BB with a diameter of 20 mm by a child younger than 4 years of age increases the risk that the BB gets stuck in the esophagus determining severe complications within two hours [3,6,10].

The early onset of severe complications within few hours from the BB ingestion/inhalation demonstrates the crucial need of a prompt medical reaction to BB injuries. Prompt diagnosis is undermined by the presence of heterogeneous symptoms associated with ingestion of batteries in children, such as drooling, gagging, dysphonia, vomiting and dysphagia (depending on the location and the type of battery) [11]. Those symptoms are aspecific and may generate confusion, when the injury is unwitnessed, with a respiratory/gastrointestinal infection, determining delays in BB injuries diagnosis and medical intervention.

The aim of this study is to provide an epidemiological review of major symptoms commonly associated with BB injuries. Analyses were performed on the epidemiological data reported from the ButtonBatteryDB (collecting cases on BB injuries obtained from published scientific literature and the ‘‘Susy Safe’’ registry).

2. Material and methods

2.1. ButtonBattery DB

The ButtonBatteryDB is a database collecting information on BB injuries in children (0–18 years of age). Data on 348 injures due to BB ingestion/inhalation have been obtained from the Registry of Foreign Body Injuries ‘‘Susy Safe’’ (269 cases) and from published scientific literature reporting case reports of FB injuries (79 cases).

The Susy Safe [12,13] is a registry reporting data on FB injuries (corresponding to the International Classification of Disease ICD-9 930-939) in children from 0 to 14 years of age. The aims of the ‘‘Susy Safe’’ registry are to designate a risk-profile of products swallowed/inhaled by children, analyze how socio-economic disparities affect the risk of FB injuries and involve stakeholders in data collection and security surveillance. Cases collected in the ‘‘Susy Safe’’ registry are anonymously reported from physicians, ORL experts, pneumologists, using a standardized Web form (more information about the Susy Safe project are available at www. susysafe.org).

Referring to cases from published literature, systematic review was performed on PubMed combining the terms: ‘‘button battery’’, ‘‘ingestion’’, ‘‘inhalation’’ and ‘‘case report’’, considering articles published up to November 2014.

Inclusion criteria applied to screen the results were: English language, FB injures caused by button battery, children from 0 to 18 years of age, injuries referred to the hospital (injuries referred to general practitioners were not included to ensure comparability with Susy Safe registry). Additionally, if the case report described multiple cases of BB injuries, data have not been aggregated, but have been reported specifically for every injured child. After the screening

procedure, we included 53 articles, corresponding to 80 single case reports eventually included in the database.

The ButtonBatteryDB included, for every case report, heterogeneous information regarding: children characteristics (age, gender and impaired mental status), features of the BB (size, corresponding to the diameter), characteristics of BB injury and hospitalization (number of BBs ingested/inhaled, symptoms, complications, procedures performed for BB injury diagnosis and removal, length of stay in the hospital).

2.2. Statistical methods

Descriptive statistics reported categorical data as percentages (absolute number) and continuous data as median (I and III quartiles). Symptoms prevalence has been estimated using a random effect model to account for between-study heterogeneity. Age and symptoms distribution has been estimated using a bootstrap (5000 runs) blocked by study, to account for betweenstudy heterogeneity. Statistical analyses were performed using R system [14] and the rms libraries [15].

3. Results

Data on 348 BB injuries were finally included in the ButtonBatteryDB. Table 1 shows the distribution of BB injuries cases according to main children and BB's characteristics. The majority of BB was found in the mouth/esophagus/stomach (ICD935) and in the nose (ICD932). Most of the children, injured by BB, were male and, in most of cases, inhaled or swallowed only one BB. Twenty-seven kids died due to complications related to BB injury. Regarding to procedures performed for BB ingestion/inhalation diagnosis and removal, most of the children underwent endoscopy (which includes different types of endoscopic procedures of both gastrointestinal – esophagogastroscopy – and respiratory – otoscopy, rhinoscopy, laryngoscopy and bronchoscopy – tracts) and only in 34 kids surgery was performed. About half of children experienced complications and the most prevalent is the developing of fistula, followed by ulceration and perforations. Referring to symptoms, dysphagia, fever and cough were showed to recur more often (Table 2).

Analyzing symptoms related to inhalation/ingestion of BB lodged in the mouth/esophagus/stomach (ICD935, which were the most prevalent cases), we found out that children had higher probability of experiencing dysphagia (30.19, 95% C.I. 17.83– 42.55), fever and cough (26.42, 95% C.I. 14.55–38.28, which is the same for both) compared to other symptoms (Table 3). Additionally, evaluating the age of these children according to symptoms, we showed that: irritability, anorexia, melena and dysphonia occur more often in children younger than one year, fever, dyspnea, cough, drooling and vomiting are more common in toddlers, while abdominal and thoracic pain occur in children from 5 years of age (Table 4). Finally, referring to the probability that symptoms showed up together, Table 5 shows that fever + cough are more likely (3.72% C.I. 1.0–6–43) to jointly show up in children with BB in mouth/esophagus/stomach (ICD935), followed by fever + dysphagia (2.66% C.I. 0.36–4.96) and by fever + irritability/crying, fever + drooling, dysphagia + irritability/crying (2.13% C.I 0.00– 4.19 overall).

4. Discussion

Our study provided an epidemiological framework of symptoms related to FB injuries caused by BB. Results demonstrated that most BB injuries involved male children, which is consistent with the literature showing that boys are more prone to swallow/inhale FB [16].

The need of analyzing specifically the epidemiology of BB injuries is related to the unique features of this type of FB. In fact, BB could lead to severe complications within few hours from the ingestion/inhalation. BB could determine severe tissues' damages due to battery's rupture but, more often, due to the generation of electrolytic current hydrolyzing tissues' fluids and producing hydroxide [6]. This substance could lead to tissues' erosion, conducting to complications such as ulceration, necrosis, perforation, fistula hemorrhage and also death [7–9].

About a half of BB injuries collected in the ButtonBatteryDB lead to complications (e.g., ulceration, necrosis, perforations and fistula). Given the high risk of severe tissue damages related to BB within few hours from ingestion/inhalation [17], the NBIH triage and treatment guidelines focus especially on the 2 h window during which batteries must be removed to avoid serious damages [18]. However, the literature reported heterogeneous symptoms related to BB injuries [11] and, especially in un-witnessed BB injuries, such heterogeneity could lead to delays in referring the child to the hospital and in making the diagnosis. Although the literature described heterogeneous symptoms related to BB injury, our epidemiological review provided interesting observations about symptoms occurring in the context of BB ingestion/ inhalation (particularly when the BB lodged in the mouth/ esophagus/stomach), identifying specific patterns of symptoms related to child's age. We ranked symptoms frequencies from the most to the less likely, demonstrating that children with BB in mouth/esophagus/stomach are more likely to experience fever, cough, irritability and dysphagia. Despite fever and cough could be misled with gastrointestinal or respiratory infections, dysphagia is a sign that could indicate the presence of a FB determining a swallowing impairment. Referring to children's age we showed that, while abdominal and thoracic pain is reported more often in 5 years old children, irritability, anorexia, melena and dysphonia occur more often in infants, while fever, dyspnea, cough, drooling and vomiting are more common in toddlers. Additionally, we analyzed symptoms that show up together, demonstrating that fever, along with (considered one at time) cough, irritability, drooling and dysphagia are more likely to jointly show up. Even if fever is not a specific symptom, its combination with another more specific symptom (e.g., dysphagia or drooling) could lead to suspect a BB injury. Our findings provide new insights in clinical presentation of BB injuries: the identification of unique patterns of symptoms related to BB injuries is useful to perform an early diagnosis (and to guarantee a prompt medical reaction), also when the injury is un-witnessed.

Additionally, beyond the clinical management, it is crucial to take into account the fact that a standardization of the BB manufacturing is needed at international level (given the great availability of tools using BB), since the current lack of standardization leads to unpredictable BB's leakages once it is ingested.

The main limitation of the study is related to the fact that symptoms were analyzed for BB found in the mouth/esophagus/ stomach, without considering if the BB was specifically found in one of these anatomical sites (the ICD 935, employed to characterize the location, referred generally to a FB in the mouth/esophagus/stomach). Sub-codes differentiating, more spe-cifically, the locations (ICD

935.0, mouth; ICD 935.1, esophagus and ICD 935.2 stomach) are available; however, they were not reported in the ButtonBatteryDB.

4.1. Final remarks

This study provided an epidemiological framework of symp-toms related to BB ingestion/inhalation in children (0–18 years of age), showing that specific pattern of symptoms could be observed according to children's age. Particularly, dysphagia has been shown to be a specific clinical marker of BB injury when the BB is located in the mouth/esophagus/stomach.

It is crucial to take into account these new findings in the clinical management of patients referring to Emergency Depart-ment with a suspect of BB injury in order to guarantee an early diagnosis and a prompt therapeutic intervention.

Conflict of interest statement

None to declare from all authors.

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Table 1
Distribution of cases according to children and BB's main characteristics. Data are percentages (absolute numbers) or I quartile/Median/III quartile respectively for categoricaland continuous variables.

	N	Ear	Nose	PharynxLarynx	TracheaBronchiLungs	MouthEsophagusStomach	Combined
		(*N* = 44)	(*N* = 112)	(*N* = 3)	(*N* = 1)	(*N* = 188)	(*N* = 348)
Age, *month*	337	60.0/72.0/108.0	36.0/48.0/60.0	10.0/11.0/35.5	48.0/48.0/48.0	12.0/24.0/48.0	24.0/36.0/60.0
Age, y*ear*	336	5/6/9	3/4/5	1/1/3	4/4/4	1/2/4	2/3/5
Male gender	332	74% (29)	63% (70)	0% (0)	100% (1)	57% (102)	61% (202)
Handicap							
No	104	100% (11)	98% (49)	100% (1)		98% (41)	98% (102)
Yes		0% (0)	0% (0)	0% (0)		2% (1)	1% (1)
Button Battery diameter	109	5.0/6.5/8.0	0.0/4.0/10.0	20.0/20.0/20.0	8.0/8.0/8.0	10.0/20.0/21.2	5.0/10.0/20.0
Number of Button Batteries	56	1.5/3.0/3.7	1.0/1.0/1.0	1.0/1.0/1.0	1.0/1.0/1.0	1.0/1.0/1.0	1.0/1.0/1.0
Procedures							
Endoscopy	187	81% (13)	79% (60)	100% (3)	0% (0)	73% (66)	76% (142)
Surgery	188	19% (3)	16% (12)	0% (0)	100% (1)	20% (18)	18% (34)
Anesthesia	198						
No		89% (25)	79% (61)	0% (0)	0% (0)	57% (51)	69% (137)
Yes		11% (3)	21% (16)	100% (2)	100% (1)	43% (39)	31% (61)
Complications	182						
No		56% (9)	75% (50)	50% (1)		39% (38)	54% (98)
Yes		44% (7)	25% (17)	50% (1)		61% (59)	47% (84)
Complications							
Ulceration	85	0% (0)	26% (5)	0% (0)		18% (11)	19% (16)
Necrosis	85	0% (0)	26% (5)	0% (0)		3% (2)	8% (7)
Perforations	85	60% (3)	32% (6)	0% (0)		8% (5)	16% (14)
Fistula	85	0% (0)	0% (0)	0% (0)		37% (22)	26% (22)
Obstruction	85	0% (0)	5% (1)	0% (0)		10% (6)	8% (7)
Sedation: Yes	25	100% (3)	83% (5)	100% (1)	100% (1)	100% (14)	96% (24)
Hospitalization length	87	0.0/0.5/1.0	0.0/0.0/1.0	1.0/1.0/1.0		0.0/1.0/3.0	0.0/1.0/2.0

Table 2
Symptoms' frequency according to the site in which the BB was found.

Symptoms		Ear	Nose	PharynxLarynx	TracheaBronchiLungs	MouthEsophagusStomach	Combined
		(N = 44)	(N = 112)	(N = 3)	(N = 1)	(N = 188)	(N = 348)
Fever	53		0% (0)	0% (0)	100% (1)	30% (14)	28% (15)
Dyspnea	53		0% (0)	100% (2)	100% (1)	17% (8)	21% (11)
Cough	53		0% (0)	0% (0)	100% (1)	30% (14)	28% (15)
Abdominal pain	53		0% (0)	0% (0)	0% (0)	9% (4)	8% (4)
Thoracic pain	53		0% (0)	0% (0)	0% (0)	4% (2)	4% (2)
Rhinorrhea	53		0% (0)	0% (0)	0% (0)	2% (1)	2% (1)
Irritability/crying	53		0% (0)	0% (0)	0% (0)	23% (11)	21% (11)
Drooling	53		33% (1)	0% (0)	0% (0)	11% (5)	11% (6)
Dysphagia	53		33% (1)	0% (0)	0% (0)	34% (16)	32% (17)
Melena	52		0% (0)	0% (0)	0% (0)	4% (2)	4% (2)
Lethargia	52		0% (0)	0% (0)	0% (0)	2% (1)	2% (1)
Dysphonia	52		0% (0)	50% (1)	0% (0)	2% (1)	4% (2)
Decreased oral intake	52		0% (0)	0% (0)	0% (0)	7% (3)	6% (3)
Vomiting	52		0% (0)	50% (1)	100% (1)	20% (9)	21% (11)
Anorexia	52		0% (0)	0% (0)	0% (0)	11% (5)	10% (5)
Epistaxis	52		33% (1)	0% (0)	0% (0)	0% (0)	2% (1)

Table 3
Estimated probability of symptoms (95% C.I.) for BB in mouth/esophagus/stomach (ICD935).

	Estimated probability (%)	95% C.I.
Fever	26.42	(14.55–38.28)
Dyspnea	15.09	(5.46–24.73)
Cough	26.42	(14.55–38.28)
Abdominal pain	7.55	(0.44–14.66)
Thoracic pain	3.77	(0–8.9)
Rhinorrhea	1.89	(0–5.55)
Irritability/crying	20.75	(9.84–31.67)
Drooling	9.43	(1.56–17.3)
Dysphagia	30.19	(17.83–42.55)
Melena	3.85	(0–9.07)
Lethargia	1.92	(0–5.66)
Dysphonia	1.92	(0–5.66)
Decreased oral intake	5.77	(0–12.11)
Emesis	17.31	(7.03–27.59)
Anorexia	9.62	(1.6–17.63)

Table 4

Median age (months) of child according to symptoms with 95% C.I. for BB in mouth/ esophagus/stomach (ICD935).

		N	Median	95% C.I.
Fever	No	32	18	(4.55–74.7)
	Yes	14	14	(5.62–34.05)
Dyspnea	No	38	16.5	(4.85–72.9)
	Yes	8	14.5	(4.17–33.9)
Cough	No	32	18	(3.7–74.7)
	Yes	14	14	(7.27–30.47)
Abdominal pain	No	43	16	(4.05–60)
	Yes	3	60	(21.05–82.8)
Thoracic pain	No	44	16	(4.07–60)
	Yes	2	60	(37.2–82.2)
Rhinorrhea	No	45	17	(4.1–70.8)
	Yes	1	13	(13–13)
Irritability/crying	No	35	18	(3.8–73.8)
	Yes	11	10	(9.25–18)
Drooling	No	41	17	(4–72)
	Yes	5	14	(10.2–45.6)
Dysphagia	No	31	14	(4.5–66)
	Yes	15	18	(5.75–67.8)
Melena	No	43	17	(4.05–71.4)
	Yes	2	11.5	(9.12–13.87)
Lethargia	No	44	16	(4.07–71.1)
	Yes	1	19	(19–19)
Dysphonia	No	44	16.5	(4.07–71.1)
	Yes	1	12	(12–12)
Decreased oral intake	No	42	16	(4.02–71.7)
	Yes	3	17	(10.3–18.9)
Vomiting	No	36	16.5	(4.8–73.5)
	Yes	9	14	(3.4–33)
Anorexia	No	40	16.5	(4.975–72.3)
	Yes	5	10	(3.4–18.9)
Epistaxis	No	45	16	(4.1–70.8)
Overall		183	24	(0–101.4)

Table 5
Estimated probabilities (as percentage with 95% C.I.) of symptoms that jointly occur for BB injuries in mouth/esophagus/stomach (ICD935).

	Fever	Dyspnea	Cough	Abdominal pain	Thoracic pain	Rhinorrhea	Irritability/ crying	Drooling	Dysphagia	Melena	Lethargia	Dysphonia	Decreased oral intake	Emesis	Anorexia	Epistaxis
Fever	7.45 (3.70–11.20)	1.60 (0.00–3.39)	3.72 (1.01–6.43)				2.13 (0.07–4.19)	2.13 (0.07–4.19)	2.66 (0.36–4.96)	1.06 (0.00–2.52)		0.53 (0.00–1.57)	1.06 (0.00–2.52)	1.60 (0.00–3.39)		
Dyspnea		4.26 (1.37–7.15)	1.06 (0.00–2.52)	0.53 (0.00–1.57)					1.60 (0.00–3.39)	0.53 (0.00–1.57)	0.53 (0.00–1.57)		1.06 (0.00–2.52)		0.53 (0.00–1.57)	
Cough			7.45 (3.70–11.20)	0.53 (0.00–1.57)		0.53 (0.00–1.57)	1.60 (0.00–3.39)	1.06 (0.00–2.52)	0.53 (0.00–1.57)	0.53 (0.00–1.57)	0.53 (0.00–1.57)	0.53 (0.00–1.57)	1.06 (0.00–2.52)	2.66 (0.36–4.96)	1.06 (0.00–2.52)	
Abdominal pain				2.13 (0.00–4.19)	0.53 (0.00–1.57)				0.53 (0.00–1.57)		0.53 (0.00–1.57)		0.53 (0.00–1.57)		0.53 (0.00–1.57)	
Thoracic pain					1.06 (0.00–2.52)											
Rhinorrhea						0.53 (0.00–1.57)	0.53 (0.00–1.57)									
Irritability/ crying							5.85 (2.50–9.20)	0.53 (0.00–1.57)	2.13 (0.00–4.19)	0.53 (0.00–1.57)			0.53 (0.00–1.57)	1.60 (0.00–3.39)	1.06 (0.00–2.52)	
Drooling								2.66 (0.36–4.96)				0.53 (0.00–1.57)	0.53 (0.00–1.57)			
Dysphagia									8.51 (4.52–12.50)	0.53 (0.00–1.57)			0.53 (0.00–1.57)	0.53 (0.00–1.57)		
Melena										1.06 (0.00–2.52)			0.00 (0.00–1.57)	0.53 (0.00–1.57)		
Lethargia											0.53 (0.00–1.57)		0.53 (0.00–1.57)		0.53 (0.00–1.57)	
Dysphonia												0.53 (0.00–1.57)				
Decreased oral intake													1.60 (0.00–3.39)		0.53 (0.00–1.57)	
Emesis														4.79 (1.74–7.84)	1.06 (0.00–2.52)	
Anorexia															2.66 (0.36–4.96)	
Epistaxis																