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National estimations of airway foreign bodies in children in the United States, 2000 to 2009

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Abstract

Objective: Identify risk factors associated with airway foreign bodies in children in the United States and report observed trends over time.

Data source: KID database (2000–2009).

Methods: ICD-9-CM codes for airway foreign bodies were used to identify patients. Risk factors were used for univariate analysis and a multivariate model to identify any increased risk of mortality. These factors were then also trended over time.

Results: Children with airway foreign bodies demonstrate similar risk factors as previously reported, such as male gender, age less than five years old, and lack of private insurance. The weighted mortality rate for pediatric inpatients with airway foreign bodies was about 2.75%. Fortunately, the rate remained relatively unchanged from 2000 to 2009. Geographically, urban hospital settings appeared to be more affected. Increased risks of mortality were noted for older age, urban hospital setting, and teaching hospital status.

Conclusions: Our findings confirm previous findings and identified that the diagnosis of airway foreign bodies in children were associated with male gender, age less than five years old, lack of private insurance, and geographic location in an urban setting. Further investigation may be warranted to provide clarity on other factors found to have increased association with mortality for quality improvement.

Keywords

airway foreign bodies; pediatric; inpatient; KID; HCUP; risk factors

Introduction

Airway foreign bodies in children are a significant public health issue and are associated with surprisingly high mortality rate.[1] Although substantial legislation exists regulating toys and other non-food items that may present a choking hazard, there is no regulation or standards for parental and/or caretaker education of high-risk aspiration food items. Food foreign bodies are the most common items identified in choking events, and boys less than 5 years of age may be at the highest risk.[2] Lack of private insurance has also been demonstrated to be a risk factor for foreign body aspiration in children. Prior reports have recommended considering insurance status as a risk factors for foreign body aspiration, noting that a potential lack of anticipatory guidance and caretaker education may play a role in a child being fed an inappropriate food item.[3] Many different types of aspirated foreign bodies in children have been described in the literature, including both inorganic and organic materials. Of the organic materials that are encountered, peanuts are often implicated. A recent experience of airway foreign bodies in children by Sink et al. (2016) reported that almost half of the causative agents were fragments of seeds and nuts.[4] The American Academy of Pediatrics (AAP) recently announced that introduction of peanuts earlier in childhood may prevent peanut food allergies in high risk infants.[5, 6] We hypothesize that previously identified clinical risk factors associated with pediatric airway foreign body aspiration will also be demonstrated in a large, nationally-representative database and that observed trends over time have not significantly shifted.

Methods

The Kids' Inpatient Database (KID) is a pediatric inpatient care database in the United States included in the Healthcare Cost and Utilization Project (HCUP), which started publishing data in 1997. It is the only all-payer pediatric-specific database in the United States and each year contains weighted information from two to three million hospital stays. The database is updated every three years and multiple data sets are available. This data set provides a unique opportunity to further characterize those children who are diagnosed with airway foreign bodies and identify areas for quality improvement. The content of the KID is de-identified and conforms to Health Information Privacy and Portability Act (HIPPA). Duke University Institutional review board (IRB) was obtained prior to this investigation.

The HCUP data elements that were assessed as individual variables included:

1. AGE – age of the patient (years)
2. DIED – indicates whether the patient died during hospitalization
3. DX1-DX25; ICD-9-DM codes: 933.1 – foreign body in larynx; 934.1 – foreign body in main bronchus; 934.8 – foreign body in other specific parts bronchus and lung; 934.9 – foreign body in respiratory tree, unspecified
4. FEMALE – indicates the gender: male or female
5. HOSP_LOCATION – indicates the location/setting of the hospital: urban or rural

6. HOSP_REGION – indicates the geographic region of the hospital in the US: Northeast, Midwest, South, West
7. PAY1 – indicates the expected primary payer: Medicare, Medicaid, private insurance, self-pay, no charge, and other)
8. RACE – indicates race and ethnicity of the patient: white, black, hispanic, Asian or Pacific Islander, Native American, or other
9. HOSP_TEACH – indicates the teaching status of the hospital: teaching or non-teaching

We combined the 2000, 2003, 2006 and 2009 editions of KID, which contain information regarding 2.5, 3.0, 3.1, and 3.4 million pediatric inpatient admissions, respectively. When weighted per KID recommendations, these represent a combined total population of more than 34 million pediatric inpatient admissions. The 1997, 2012, and 2015 editions of the KID database were not used because not all data elements were available in 1997; in 2012 and 2015, the method in which the data was coded was changed and only allowed for cross-sectional analysis. Trends over time were also assessed for any changes regarding risk factors. Payer status was separated into private insurers (PAY1 = 3) and non-private payers including public sources, uninsured, or other (PAY1 = 1, 2, 4, 5, and 6).

Summary data is presented as well as separate analyses of different clinical risk factors. Available data were utilized, as in some instances, not all frequency data was reported. A simple linear regression model was fit to assess the temporal trend of the age of pediatric patients with foreign body aspiration at admission. For each data set year, a Wald-Chi-squared statistic test was used to compare if there was any association over time among the following clinical factors: gender, race (black, white, Hispanic/Asian/other), insurance payer (private/non-private), hospital location (rural/urban), hospital region (Midwest, Northeast, South, and West), and mortality. A multivariate logistic regression model was used to model mortality during hospitalization due to an airway foreign body as a function of the following variables: year of the survey, age of the patient, race of the patient, insurance type, hospital location, and teaching status.

The complexity of the survey sample design, including stratification, clustering, and weighting was considered for all statistical inferences. All statistical analyses were conducted with SAS software (SAS Institute Inc., 2015, Cary, NC). The threshold for assessing statistical significance was set to level $\alpha = 0.05$, thus p-values $> .05$ were considered non-significant.

Ethical considerations

Duke University Medical Center Institutional review board (IRB) was obtained prior to this investigation. The content of the KID is de-identified and conforms to Health Information Privacy and Portability Act (HIPPA). The authors abided by the submitted data use agreements.

Results

The mean age at admission for pediatric patients with airway foreign bodies from the KID database from 2000 – 2009 was 4.66 $\pm$ 0.02 years. Table 1 summarizes the mean age at the time of admission and total weighted frequency data for gender, insurance payer, hospital location, race/ethnicity, hospital region, and mortality. Figure 1 shows the overall frequency of foreign body aspiration by age from 2000 to 2009. Of note, over two thirds of the total cases occurred in patients less than 4 years old. For children above 4 years old, the frequency stabilized. The majority of airway foreign bodies occurred in children from age 0 to 3 years (38% for age 0–1 years; 15% age 1–2; and 11% age 2–3). Furthermore, the age at admission for children with airway foreign bodies significantly increased over time, $p = 0.0024$.

The total weighted frequency for gender was 11,668 (42.28%) females and 19,479 (57.72%) males. The ratio of males and females with foreign body aspiration did not significantly change over the study period, $p = 0.861$. Male children demonstrated a consistently higher incidence of experiencing foreign body aspiration than females. There was a statistically significant increase in the proportion of children with the diagnosis of airway foreign bodies with non-private insurance over time from 2000 to 2009, $p = 0.0001$. Urban locations had a significantly higher incidence of children with airway foreign bodies, and these cases increased in proportion for urban hospitals over time from 2000 to 2009, $p = 0.0001$. There was no significant change in the proportion of race/ethnicity over the time period examined, $p = 0.47$. No geographic region of the country seemed to be more burdened or demonstrated increased incidence of this problem, and this did not change over the investigated time, $p = 0.6498$.

The overall weighted frequency of mortality with the diagnosis in pediatric patients of airway foreign body aspiration for the years 2000, 2003, 2006, and 2009 was 2.75%. (Table 1) There was no significant increase in the rate of mortality in children associated with airway foreign bodies over time, $p = 0.1891$.

In the multivariate analysis, age ($p < 0.0001$), hospital location in an urban setting ($p = 0.0320$), and teaching hospital status ($p = 0.0256$) were significantly associated with an increased risk of death. Estimated odds ratios (OR), associated 95% confidence intervals and p-values for the individual variables are presented in Table 2. Each one-year increase in patient age was associated with a 9% increase in odds of death, OR = 1.093, 95% CI: [1.07, 1.11]. Hospital location was also a significant predictor of mortality. The odds of mortality in urban hospitals were 2.89 times higher than rural hospitals, when other covariates were held constant, 95% CI: [1.095, 7.624]. Teaching hospitals also were associated with statistically significant higher rates of mortality, as children were 1.487 times more likely to die when holding other covariates constant, 95% CI: [1.050, 2.107].

Discussion

The KID database provides a unique ability to examine the problem of airway foreign bodies, as this tends to occur in children and to be managed in an inpatient setting. It also

may help to identify areas for quality improvement. Worldwide, airway foreign bodies are the leading cause of accidental infantile deaths and the fourth most common cause of death among preschool aged children. [7] Prior attempts at systematic review or other larger scale investigations have not been particularly effective at evaluating clinical risk factors; but even with the given heterogeneity of primary studies, the importance of preventative measures is emphasized. [8] Our study utilized a different approach at looking at this problem on a national scale and also adds a unique perspective of evaluating trends over time. We chose not to narrow the results by selecting out those children who underwent bronchoscopy as to not miss cases, as there are instances of events that may not have underwent a procedure or intervention.

This is an important clinical condition affecting children, as complications related to foreign body aspiration in children can be catastrophic. [1] As revealed by our investigation of the years between 2000 and 2009, it appears that the extrapolated national mortality rate with children with a diagnosis of an airway foreign body was 2.75% (standard error = 0.18%). Death, unfortunately, may result after foreign body aspiration, which underscores the importance of recognition and prompt treatment.[9, 10] Fortunately, our data and results suggest that the associated mortality did not increase in incidence over the near-decade spanning between 2000 and 2009. However, variables that were noted to be associated with increased rates of mortality included increasing age, urban hospital location, and teaching hospital status. Our current investigation was not equipped to further understand these findings, and further study may be helpful to try to understand these results. This may be explained by varying clinical severity of disease or case mixbased on age and the location of the treating hospital.

Our findings confirm other prior reports of risk factors for airway foreign body aspiration in children including age less than five years old, male gender, and insurance status. [2–4] Insurance status may be a unique factor specific the US population, thereby limiting our findings to be generalized internationally. But it may act as a surrogate for socioeconomic status, which may be easier to quantify and compare across diverse populations in future investigations. This investigation is unique and provides an additional perspective, as we were able to provide temporal trends. We also found that boys less than five years of age had the highest incidence and that the gender relationship and proportion appeared to be maintained over time. Anticipatory guidance efforts for possible prevention of airway foreign body aspiration events in children may be most efficient and optimized by focusing on boys less than 5 with lack of private insurance. School-aged and focused educational efforts may not be that effective given that most cases occur in children before that age.

Our study has some significant potential limitations, as large, national cross-sectional analysis may have significant issues with identification of specific similar cases, and there may be significant clinical variability within the included cases. However, with the diagnosis of airway foreign bodies, we feel that there is little background noise with other overlapping diagnoses. The airway foreign body cases may have also not been accidental aspiration, and other etiologies exist, such as iatrogenic cases of aspirated dentition, which may occur during other general anesthesia procedures. In these cases, anticipatory guidance or other educational efforts would not be particularly useful for prevention of accidental airway

foreign body aspiration. Furthermore, the KID database may not be representative of the pediatric population as a whole, so making generalizations and comparisons may need to be taken with caution. We feel that our study also provides several unique aspects to our current knowledge base regarding airway foreign bodies in children, including the trend of clinical factors over time.

This may be an opportune time to further investigate why there appeared to be a significant disparity regarding mortality rates for airway foreign bodies in children when encountered in an urban location and teaching hospital status. Our results indicate that children with airway foreign bodies were more likely to be encountered in urban hospital settings, and the burden of cases seemed to significantly increase in urban hospital settings over time. Given our findings, it may be beneficial to understand these trends from a public health perspective.

Conclusion

Clinical risk factors associated with airway foreign bodies in children included male gender, age less than five years, lack of private health insurance, and urban hospital location. There was a significant increase in the proportion of these children in urban settings and those lacking private health insurance over time. Fortunately, mortality rates have remained stable over time. Increased mortality rates were noted with increasing age, urban hospital setting, and teaching hospital status. Further investigation to understand the disparity in these factors is warranted.

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Figure 1.

Plot bar histogram with 95% confidence limits of overall frequency by age from 2000 – 2009.

Table 1.

National estimates for mean age, gender, insurance payer, hospital location, race/ethnicity, hospital region, and mortality of pediatric patients with an admission diagnosis of airway foreign body aspiration from 2000 to 2009.

Year	2000	2003	2006	2009	Total
Mean age (years, 95% confidence interval)	4.2 (3.84 – 4.56)	4.14 (3.73 – 4.54)	4.24 (3.91 – 4.57)	5 (4.57 – 5.43)	4.66 (4.62 – 4.7)
Mortality rate (% , standard error)	3.11 (0.53)	2.19 (0.29)	2.71 (0.33)	3.01 (0.3)	2.75 (0.18)
Number of mortalities	129.93	106.12	133.51	171.56	541.12
Gender					
Male (% per individual year)	2366 (56.73)	2784 (58.21)	2819 (57.89)	2819 (57.89)	11243 (57.72)
Female (% per individual year)	1804 (43.27)	1999 (41.79)	2051 (42.11)	2383 (42.12)	8236 (42.48)
Insurance payer					
Non-private payer (%)	2023 (48.58)	2698 (53.94)	2920 (59.39)	3404 (59.7)	10954 (55.84)
Private insurance payer (%)	2141 (51.42)	2227 (46.06)	1997 (40.62)	2298 (40.3)	8663 (44.16)
Hospital location					
Rural (%)	343.3 (8.27)	319.24 (7.24)	267.23 (5.6)	233.53 (4.52)	1163 (6.29)
Urban (%)	3807 (91.73)	4093 (92.76)	4504 (94.4)	4930 (95.48)	17334 (93.71)
Race/ethnicity					
Black (%)	537.37 (15.45)	592.77 (16.48)	617.48 (16.53)	757.98 (16.24)	2506 (16.19)
Hispanic/Asian/other (%)	919.62 (26.44)	941.83 (26.18)	1154 (30.89)	1375 (29.48)	4391 (28.37)
White (%)	2021 (58.11)	2062 (57.34)	1965 (52.29)	2532 (54.28)	8580 (55.44)
Hospital region					
Midwest (%)	813.8 (19.51)	1425 (29.36)	1288 (26.15)	1590 (27.87)	5117 (26.03)
Northeast (%)	661.04 (15.85)	635.59 (13.1)	665.79 (13.52)	699.73 (12.26)	2662 (13.54)
South (%)	1555 (37.29)	1676 (34.55)	1725 (35.03)	1872 (32.8)	6829 (34.74)
West (%)	1141 (27.36)	1116 (22.99)	1246 (25.3)	1545 (27.07)	5048 (25.68)

Table 2.

Estimated odds ratios (OR) of mortality from multivariate logistic regression model.

Variable	Odds Ratio (OR)	95% Wald Confidence Interval	Pr > t
Year – 2003 vs 2000	0.754	0.467 – 1.218	0.2489
Year – 2006 vs 2000	0.861	0.546 – 1.360	0.5217
Year – 2009 vs 2000	0.786	0.505 – 1.223	0.2849
Age	1.093	1.072 – 1.114	<.0001
Race – black vs white	1.005	0.684 – 1.478	0.9786
Race – Hispanic/Asian/other vs white	1.266	0.922 – 1.740	0.1453
Insurance – private vs non-private	0.876	0.658 – 1.166	0.3627
Hospital location – urban vs. rural	2.890	1.095 – 7.624	0.0320
Teaching vs non-teaching hospital	1.487	1.050 – 2.107	0.0256