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Morbidity and Mortality in Children Undergoing Bronchoscopy for Foreign Body Removal

Christopher A. Roberts, MD; Michele M. Carr, DDS, MD, PhD

Objectives/Hypothesis: Analyze morbidity and mortality among children undergoing bronchoscopy for foreign body removal.

Study Design: Multicenter retrospective review using the American College of Surgeons Pediatric National Surgical Quality Improvement Program from 2014 and 2015.

Methods: Patients were identified using Current Procedural Terminology code 31635. Demographics, time to surgery, operative times, hospitalization time, and complications were collected. Multivariate logistic regression was used to identify predictive factors for major adverse events.

Results: Three hundred thirty-four patients were included (mean age 3.7 years, 59.0% male). Preoperative sepsis syndrome was present in 5.7% of patients and 8.1% had asthma. Of the patients, 51.1% percent of patients had a tracheostomy. Bronchoscopy was performed by an otolaryngologist (65.4%) or a pediatric surgeon (33.1%). Mean operative time was 27.4 minutes, whereas mean total operating room time was 54.6 minutes. Airway foreign bodies were located in 269 patients (80.5%), with 62.5% being located in the mainstem bronchus. Operative time was longer when foreign bodies were in the mainstem bronchus or distal to it. Mean time to surgery from admission was 0 days, and mean duration of hospitalization was 1 day. One patient (0.3%) required reoperation for respiratory reasons, and three (0.9%) required readmission for related reasons. No patients remained hospitalized at 30 days. Two (0.6%) had a postoperative pneumonia, and two (0.6%) required reintubation. One patient death (0.3%) occurred within 2 weeks of bronchoscopy. No significant differences were identified in operative time, time to surgery, or hospitalization time based on age, gender, presence of a tracheostomy, or surgical specialty.

Conclusions: Bronchoscopy for identification and removal of airway foreign bodies had minimal morbidity in this group.

Key Words: Pediatric airway, foreign body, bronchoscopy, morbidity, statistics.

Level of Evidence: 2b.

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INTRODUCTION

Airway foreign bodies (AFB) can be difficult to diagnose and can be associated with catastrophic outcomes. Presentation can be delayed, particularly if aspiration is not witnessed by a caregiver. Symptoms can be absent or nonspecific. Almost 2,000 children are admitted yearly to US hospitals for this diagnosis, and the mortality rate has been reported to be up to 2.5%. Bronchoscopy is the only way to rule out an airway foreign body as chest radiographs can be normal. Morbidity of this procedure in the context of modern anesthesia and surgical equipment advances has not been well described in the literature, and this is important information in the decision to proceed to the operating room. Recent attention to potential neurocognitive deficits in young children undergoing general anesthesia may result in concern during the clinical decision making for these patients, despite the lack of supporting evidence from ongoing studies.

The purpose of this study was to assess significant complications following bronchoscopy for airway foreign bodies in children.

MATERIALS AND METHODS

This research was reviewed by the local institutional review board and found to be exempt (study ID #5572). Data were taken from the 2014 and 2015 National Surgical Quality Improvement Program (NSQIP)–Pediatric public use file available from the American College of Surgeons. Data collection methods for the NSQIP-Pediatric have been described and include risk-adjusted patient data from procedures sampled in 8-day cycles taken from participating hospitals. Data accuracy is ensured by certified nurse reviewers at each participating institution who are specifically trained to collect patient data based on standardized definitions. Eighty sites were included in 2015 and 50 in 2014. Over 100 variables were collected for each surgical case, including patient demographics and 30-day postoperative outcomes. All patients were under 18 years of age.
TABLE I.
Comorbidities in Children Undergoing Bronchoscopy for Airway Foreign Bodies.

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma</td>
<td>8.1</td>
</tr>
<tr>
<td>Chronic lung disease</td>
<td>4.8</td>
</tr>
<tr>
<td>Structural pulmonary or airway disorder</td>
<td>10.7</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>5.1</td>
</tr>
<tr>
<td>Required oxygen supplementation preoperatively</td>
<td>6.6</td>
</tr>
<tr>
<td>Required ventilation within 48 hour of procedure</td>
<td>5.1</td>
</tr>
<tr>
<td>Recent pneumonia for which patient was on antibiotics at the time of surgery</td>
<td>1.2</td>
</tr>
<tr>
<td>Congenital malformation including prematurity</td>
<td>4.8</td>
</tr>
<tr>
<td>No cardiac risk factors</td>
<td>94.9</td>
</tr>
<tr>
<td>Previous cardiac surgery</td>
<td>2.4</td>
</tr>
<tr>
<td>Seizure disorder</td>
<td>2.7</td>
</tr>
<tr>
<td>Gastroenterological disorder</td>
<td>6.9</td>
</tr>
<tr>
<td>Neuromuscular disease</td>
<td>0.9</td>
</tr>
<tr>
<td>Sepsis or SIRS</td>
<td>5.7</td>
</tr>
</tbody>
</table>

SIRS = systemic inflammatory response syndrome.

age. General complications were documented. There is currently no collection of procedure-specific complications. Sampling was done by selecting for Current Procedural Terminology code 31635, “Bronchoscopy, rigid or flexible, with removal of foreign body.” Age, gender, race, preoperative comorbidities, American Society of Anesthesiologists (ASA) class, specialty of the surgeon performing the procedure, operative times, anesthesia times, length of hospital stay, reoperations and readmissions, and postoperative complications were included in this study.

Data were analyzed with SPSS 24 (IBM, Armonk, NY), using nonparametric methods to compare study groups and logistic regression was employed.

RESULTS

We identified 335 patients. One with a very extended stay who did not have a postoperative diagnosis of an AFB was considered an outlier and was removed from the analysis, leaving 334 in the study group. There were 137 (41.0%) female and 197 (59.0%) male children in this group. Average age was 3.7 years (range 0.6 to 17.9 years). Racial classification included 70.4% who were white, 12.8% who were African American, 1.8% who were Asian, 0.6% who were Native American or Pacific Islander, and in 14.3% race was not specified.

Admission through the emergency department occurred in 76.9%, 20.4% came from home, a clinic, or doctor’s office, and 1.2% were transferred from another hospital. The rest were categorized as “other.”

Comorbidities are shown in Table I. No patients had cystic fibrosis, immune disease, diabetes, liver disease, renal failure, or were on dialysis. Two or fewer patients had cerebral palsy, a bleeding disorder, or other hematological disorder. One was comatose at the time of surgery, and three had had cardiopulmonary resuscitation (CPR) within 7 days of surgery. Oral or parenteral steroid use occurred in 4.5% within 30 days of surgery (not including inhaled or topical, or one dose within 24 hours of surgery). ASA class is shown in Table II.

Most patients (72.8%) underwent this procedure within 24 hours of admission. The procedure was done 1 day later in 23.8%, whereas 2.4% had it at 2 to 3 days later. The longest interval was 21 days. Mean total length of stay (LOS) was 1.28 days (95% confidence interval: 1.00-1.55). LOS was 0 days for 34.3%, 1 day for 47.2%, with the longest stay 25 days. Postoperative ventilation occurred in 5.1%, whereas 94.9% were not ventilated postoperatively. Of those who were ventilated postoperatively, the average number of days was 3.82 (range, 1–18). None were in the hospital at 30 days postoperatively. One patient death occurred within 2 weeks of bronchoscopy. This patient was intubated prior to bronchoscopy, on inotropes and supplemental oxygen, and had CPR within 7 days of surgery; this child had a prolonged operative time and had postoperative bleeding.

Seventeen (5.1%) patients had a tracheostomy. There were no differences between the group with a tracheostomy and the group without one for age, days to bronchoscopy, LOS, or operating room times except anesthesia emergence time (15.0 minutes for the tracheostomy group vs. 20.98 minutes for patients without a tracheostomy) (P = .013).

The procedure was done by an otolaryngologist or pediatric otolaryngologist (ear, nose, and throat [ENT]) in 65.4% of cases. Most of the remainder had it done by a pediatric surgeon (33.2%) (PS). There was a significant difference in anesthesia induction time (12.7 minutes for ENT vs. 16.5 minutes for PS [Mann-Whitney P = .006]) and anesthesia emergence time (18.99 minutes for ENT vs. 24.0 minutes for PS [Mann Whitney P = .033]). There were no differences in total operative time, surgery time, patient age, LOS, or days from admission to surgery. One patient had an esophagoscopy and foreign body removal at the same time. No children had a tracheotomy performed at the same time.

There were very few reported complications. Only one child (0.3%) returned to the operating room OR for a respiratory reason (acute bronchitis). Three (0.9%) were readmitted for a related reason, two for respiratory infection and one for fever; none had been reintubated while in the hospital. Two patients (0.6%) had postoperative pneumonia diagnosed. Two (0.6%) were reintubated, one of whom had postoperative pneumonia. One had an episode of postoperative bleeding, and one was diagnosed with shock. Eight patients (2.4%) were ventilated for 1 day postoperatively, and nine patients (2.7%) were ventilated...
TABLE III. Location of Airway Foreign Body (N = 269).

<table>
<thead>
<tr>
<th>Location</th>
<th>No.</th>
<th>%*</th>
<th>Mean Age, yr</th>
<th>Mean Operative Time, min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larynx</td>
<td>20</td>
<td>7.43</td>
<td>3.39</td>
<td>18.25</td>
</tr>
<tr>
<td>Trachea</td>
<td>16</td>
<td>5.85</td>
<td>4.61</td>
<td>18.25</td>
</tr>
<tr>
<td>Mainstem bronchus</td>
<td>168</td>
<td>62.45</td>
<td>3.62</td>
<td>25.29</td>
</tr>
<tr>
<td>Other specified parts</td>
<td>19</td>
<td>7.06</td>
<td>3.55</td>
<td>31.45</td>
</tr>
<tr>
<td>bronchus or lung</td>
<td>42</td>
<td>15.61</td>
<td>1.79</td>
<td>30.37</td>
</tr>
<tr>
<td>Pharynx</td>
<td>4</td>
<td>1.49</td>
<td>2.70</td>
<td>11.33</td>
</tr>
</tbody>
</table>

*Percent of those with airway foreign body as a postoperative diagnosis

for more than 1 day postoperatively. All of these children were grouped together with patients who had a stay of 2 days or longer, and were designated the any complication (AC) group (N = 43 in total). When compared to the unaffected group (N = 291), we found significant differences in operative times (Mann-Whitney P < .001), anesthesia times (Mann-Whitney P < .001), ASA class (Mann-Whitney P < .001), incidence of preoperative neuromuscular disease (Fisher exact test P = .045), and use of oral/parenteral steroids in the 30 days prior to surgery (Fisher exact test P = .031). There were no differences in other preoperative morbidities, age, gender, location of foreign body, or type of surgeon performing the surgery. Logistic regression including these five significant variables revealed that anesthesia time (P = .012) and ASA class (P < .005) were significantly associated with a child being in the AC group.

Airway foreign body was kept as the postoperative diagnosis in 80.5% of patients. Locations are listed in Table III, along with mean age and operative times. Operative time was compared for the four specified airway sites—larynx, trachea, mainstem bronchus, and bronchus/lung, and there was a significant difference (Kruskal-Wallis test for all four together, P = .022). Pairwise comparisons showed that foreign bodies in the mainstem bronchus or below took significantly longer than did ones in the larynx and trachea. There was also an age difference with children having tracheal foreign bodies being older when compared pairwise with children having laryngeal foreign bodies (Mann-Whitney P = .046) or mainstem bronchus foreign bodies (Mann-Whitney P = .016). Children with an unspecified airway site for the foreign body were not included in these comparisons, because we were not able to discern meaning from this category.

There were no differences in surgical specialty, length of time from admission to surgery, total length of stay, anesthesia times, postoperative reintubation, or readmission or return to OR when these four sites were compared.

**DISCUSSION**

The NSQIP-Pediatric database includes a somewhat random selection of cases from participating hospitals, so the study group represents a segment of the population of patients with this complaint. The purpose of this database is to examine and compare complications for procedures done at different sites and by different surgeons to determine quality and potentially to improve it. Currently, there are no procedure-specific complications included in this database. The advantage to using this database for a study of this nature is that the information was collected for the purpose of quality assessment, unlike many other databases where the information is collected for billing purposes.

It is a disadvantage that procedure-specific complications are not included, but in the case of the present study, the main complications of potential interest are included—pneumonia, return to OR, subsequent procedures, readmissions for related reasons, intubations, and prolonged hospitalizations.

We found very few complications, which included 0.6% for pneumonia or reintubation (all of whom had an AFB), 0.9% for readmission (two of whom had an AFB), and 0.3% for reoperation for a respiratory reason (which was not related to an AFB in this specific case). In Zhang et al.’s group, complications were seen in 9%, most of which were laryngeal edema or laryngospasm or severe hypoxemia. Pneumothorax or atelectasis occurred in 1%. Prolonged hospital stay (>2 weeks) or ICU admission occurred in 33 patients (about 1%); the percentage of patients with preoperative respiratory symptoms, complications, and negative bronchoscopies increased between 2005 and 2010. They felt that preoperative respiratory symptoms predicted postoperative complications. An Algerian study of children, most of whom had bronchoscopies for an AFB, spanning the years 1989 to 2012, showed a complication rate of 0.29%. Foltran et al. reported a pooled proportion for pneumonia related to an AFB to be 0.106, one of the most frequently encountered complications; pooled proportion for overall complications was 0.157.

In the NSQIP group, the average length of stay was just over 1 day, much shorter than described using the Kids’ Inpatient Database (KID) in 2003, where average length of stay was 6.4 days. The latter group included children with esophageal foreign bodies. Only 52% of this group underwent bronchoscopy. Moreover, the KID group had an average of 2.4 procedures done. The more recent NSQIP group had far fewer procedures, suggesting that management of children with a suspected AFB has changed over the last 10 years.

The mortality rate in this group was 0.3%, lower than previously reported by Johnson et al., who found a 2.5% mortality rate using the KID for 2003 to 2012. This was reviewed for a diagnosis of an AFB using *International Classification of Diseases, Ninth Revision* codes, so this group would have included patients who had not undergone bronchoscopy. Foltran et al.’s meta-analysis of AFBs in children reported a pooled proportion of mortality of 0.062%; again, this did not include only children undergoing removal of the AFB by bronchoscopy. In Zhang et al.’s retrospective review of patients in their institution who had undergone rigid bronchoscopy for foreign body aspiration between 1991 and 2010, mortality rate was 0.3%,
mortality rate of 0.26%. These reports suggest that bronchoscopy is associated with a decreased mortality rate in AFBs when compared to all children with this diagnosis.

The point of Johnson et al.’s study was to compare outcomes based on location of the foreign body. In their group 52.2% of the foreign bodies were located in the larynx, compared to 7.43% in our group, and 21.5% of their foreign bodies were in the bronchus, compared to 62.83% of our group. This shows that these two groups are very different. It is likely that patients with a laryngeal foreign body in extremis in the emergency department would undergo direct laryngoscopy in that setting to remove the obstruction, so that would not appear in our dataset. In our study, location of the foreign body was associated with differences in operative times and age of the child, but not outcomes. We did not find the same age variation as Johnson et al. did for foreign body location. In our group, over 80% of patients retained the diagnosis of an AFB postoperatively, as compared to 37% in Shah et al.’s study using the 2003 the KID. This may reflect the retrospective nature of this database; coding for a procedure may not reflect the clinical judgment that originally brings a patient to the OR. The current higher retrieval rate likely is a sequela of the methodology of the present study and cannot be used as a benchmark for managing children with a suspected AFB.

We found that about two-thirds of airway foreign bodies were treated operatively by otolaryngologists, and this likely reflects referral patterns and availability of specialists. There were no significant differences in outcomes based on specialty. There were shorter anesthesia times, both induction and emergence, for cases performed by otolaryngologists. Otolaryngologists and anesthesiologists share the airway on a daily basis and likely have developed efficient routines to do so.

Limitations to this study include the fact that the Current Procedural Terminology code used does not specify whether bronchoscopy is rigid or flexible. The database does not include information about presentation and indication for surgery, nor does it include information about minor procedure-specific complications such as laryngeal edema not requiring reintubation. Despite these limitations, these data are useful to study this procedure.

CONCLUSION

Although the literature shows that an AFB in children has a high mortality rate overall, these data suggest that bronchoscopy as part of their management has low morbidity and mortality. This study reflects many surgeons at multiple centers and a recent patient cohort, so results are directly applicable to today’s patient population. Modern pediatric bronchoscopy can be safely employed in the care of these patients.

BIBLIOGRAPHY