Published in final edited form as:

Paediatr Anaesth. 2018 March ; 28(3): 218–225. doi:10.1111/pan.13319.

Identification of perioperative pulmonary aspiration in children using quality assurance and hospital administrative billing data

Lisa Eisler¹, Grace Huang¹, Ka-Eun M. Lee¹, Jennifer A. Busse¹, Ming Sun², Albert Y. Lin¹, Lena S. Sun³, and Caleb Ing^{1,4}

¹Anesthesiology, Columbia University, New York, NY, USA

²Biostatistics, Mailman School of Public Health, New York, NY, USA

³Anesthesiology and Pediatrics, Columbia University, New York, NY, USA

⁴Epidemiology, Mailman School of Public Health, New York, NY, USA

Summary

Background: Perioperative aspiration is a rare but potentially devastating complication, occurring in 1–10 per 10 000 anesthetics based on studies of quality assurance databases. Quality assurance reporting is known to underestimate the incidence of adverse outcomes, but few large studies use supplementary data sources. This study aims to identify the incidence of and risk factors for perioperative aspiration in children using quality assurance data supplemented by administrative billing records, and to examine the utility of billing data as a supplementary data source.

Methods: Aspiration events for children receiving anesthesia at a tertiary care pediatric hospital between 2008 and 2014 were identified using (i) a perioperative quality assurance database and (ii) hospital administrative billing records with International Classification of Diseases, Ninth Revision Clinical Modification coded diagnoses of aspiration. Records were subject to review by pediatric anesthesiologists. Following identification of all aspiration events, the incidence of perioperative aspiration was calculated and risk factors were assessed.

Results: 47 272 anesthetic cases were evaluated over 7 years. The quality assurance database identified 20 cases of perioperative aspiration occurring in surgical inpatients, same-day admissions, and outpatients. Using hospital administrative data (which excludes outpatients with shorter than a 24-hour stay), 9 cases of perioperative aspiration were identified of which 6 had not been found through quality assurance data. Overall, International Classification of Diseases, Ninth Revision coding demonstrated a positive predictive value of 94.5% for any aspiration event; however, positive predictive value was <4% for perioperative aspiration. A total incidence of 5.5 perioperative aspirations per 10 000 (95% CI: 3.7–8.0 per 10 000) anesthetics was found.

Correspondence Lisa Eisler, Department of Anesthesiology, Columbia University, New York, NY, USA., LDL2113@cumc.columbia.edu.

ETHICAL APPROVAL

Ethics approval for the study was granted on July 21, 2017 by the Columbia University Human Research Protection Office, under protocol AAAD7712(M00Y10).

CONFLICT OF INTEREST

The authors report no conflict of interest.

Conclusion: Quality assurance data offer an efficient way to measure the incidence of rare events, but may underestimate perioperative complications. International Classification of Diseases, Ninth Revision codes for aspiration used as a secondary data source were nonspecific for perioperative aspiration, but when combined with record review yielded a 30% increase in identified cases of aspiration over quality assurance data alone. The use of administrative data therefore holds potential for supplementing quality assurance studies of rare complications.

Keywords

hospitals; intraoperative complications; pediatric; perioperative period; quality assurance; respiratory aspiration; respiratory aspiration of gastric contents

1 | INTRODUCTION

Perioperative aspiration is currently viewed as a rare but potentially devastating complication, with reports from large, retrospective, quality assurance (QA) database studies showing an incidence of <1 to 4.7 in 10 000 anesthetic cases in adult and mixed age populations.^{1–5} A subgroup analysis of one of these studies found that children aged 0–9 years old experienced twice the risk of aspiration compared to other ages.² Subsequent pediatric-specific studies have reported an incidence ranging from ~1 in 10 000 to as high as 10.2 in 10 000.^{6–12}

Analysis of risk factors for aspiration in adults has found ASA status and emergency surgery to be significantly associated with higher incidence of aspiration.⁴ Studies in children alone as well as in mixed populations confirm with varying consistency these risk factors, and additionally suggest that risk for aspiration is increased in children of younger age and higher body weight.^{1,7,8,11,12} A recent study, based on the Pediatric Sedation Research Consortium's database, did not identify lack of *nil per os* status as a risk factor for aspiration in the largest study to date of pediatric sedation cases.⁶ Though numerous sequelae have been described in the above pediatric studies, such as unplanned admission, prolonged intubation, sepsis, and other morbidity, there have been no mortalities described.

Published studies examining perioperative pulmonary aspiration in children rely nearly exclusively on data derived from large voluntary databases such as QA databases. While the use of QA databases can efficiently assess rare outcomes in large populations, these data are captured through voluntary reporting from the medical provider, and as a result have been found to underreport complications.^{13–16} The goals of this study were to (i) determine whether the use of multiple data sources including QA data can enhance the identification of aspiration events at a single tertiary medical center, and (ii) evaluate the incidence of and risk factors for perioperative aspiration in children at our center using multiple sources of aspiration reporting.

2 | MATERIALS AND METHODS

Following IRB approval, perioperative pulmonary aspiration was identified using 2 independent data sources at Columbia University Medical Center (CUMC): the pediatric

quality assurance (QA) database and hospital administrative billing records from January 2008 to December 2014. All patients aged 18 years or younger were included in this study.

2.1 | Quality assurance database

Perioperative QA data have been recorded for all pediatric operating room and offsite procedures at CUMC beginning in 2008.¹⁷ All QA forms are completed by the anesthesia provider at the end of each procedure, with paper QA forms used from 2008 to 2009, and electronic QA reports from 2010 onwards. All QA reports record demographic data including age, height, and weight of the child, sex, American Society of Anesthesiology (ASA) physical status, emergency status, location of procedure (operating room or offsite), and other patient comorbidities. Details of the anesthetic technique, postoperative vital signs, and adverse events including episodes of perioperative pulmonary aspiration are also recorded.

2.2 | Hospital administrative billing data

Hospital administrative billing data are generated based on information from the medical record, and typically includes patients requiring at least a 24-hour stay in the hospital. Upon discharge, data regarding the principal diagnosis and procedures as well as any additional diagnoses and procedures are extracted from the medical record by professional coders.¹⁸ For this study, the hospital administrative data were surveyed for all inpatient admissions in which children received an anesthetic according to anesthesiology departmental billing records from the time period 2008 to 2014. Hospital discharge billing records for all of these admissions were then requested from the hospital Clinical Data Warehouse, which house all hospital administrative data and electronic health records. Cases of aspiration were identified using International Classification of Diseases 9th Revision (ICD-9) codes 997.32 (postprocedural aspiration pneumonia) and 507.0 (pneumonitis due to inhalation of food or vomitus). A formal data collection form was completed to gather data on each ICD-9-coded aspiration.

2.3 | Chart review of aspiration cases

Cases identified with either of the above ICD-9 codes for aspiration in the hospital discharge billing records were subject to an initial in-depth chart review by a pediatric anesthesiologist to capture any and all potential aspiration events. Aspiration events in the initial chart review were identified as any possible occurrence of pulmonary aspiration of gastric contents with documentation occurring within 7 days of the surgery and anesthesia. This broad review of records up to 1 week postoperatively was performed in order to reduce the risk that any perioperative aspiration events were missed due to delayed reporting. Perioperative aspiration was defined as any documentation of perioperative vomiting, gastric material in the airway, or physical exam or radiographic evidence of findings consistent with aspiration. The records reviewed for each case included the anesthetic record, postanesthesia care unit (PACU) notes, admission and discharge notes, daily progress notes, as well as radiology reports. In addition to identifying potential perioperative aspiration events, the chart review also determined whether a coded aspiration was (i) present on admission based on documentation of aspiration in the admission or emergency room notes, (ii) present prior to the procedure based on documentation of aspiration before the procedure was performed,

(iii) occurring outside of the perioperative period defined as aspiration documented in records >7 days after the procedure, or (iv) no aspiration documented in any of the records in the chart.

Records that were identified with any possibility of perioperative aspiration on initial review were subsequently independently reviewed by 2 other pediatric anesthesiologists in order to determine if the event was a verified perioperative aspiration. Confirmation of an aspiration event required documentation of perioperative vomiting and either (i) the presence of gastric material during suctioning, laryngoscopy, or bronchoscopy, or (ii) if the tracheal/bronchial airways were not examined, physical exam or radiographic findings consistent with aspiration.¹¹ Physical exam findings consistent with aspiration included desaturation and new-onset cough, wheeze, or crackles in the chest, while radiographic findings consistent with aspiration included new focal infiltrates, particularly of the right middle lobe.¹¹

The aspiration was deemed perioperative if it occurred between the time at which the patient entered the operating room and 2 hours after completion of the procedure. Any discrepancies resulting from this secondary review were resolved with further review and discussion and required agreement between the 2 reviewers.

These verified perioperative aspiration events were then also assessed to determine patient comorbidities, initial airway management, and phase of detection of aspiration. They were also assessed for escalation of care including treatment with antibiotics,¹² additional airway management such as unplanned intubation, unplanned hospital admission, and unplanned ICU admission. Lastly, the cases were evaluated for the presence of any long-term sequelae at discharge such as hypoxic brain injury, new neurologic deficits, complications related to prolonged intubation, or complications of infection/sepsis.

Cases identified as perioperative aspiration in the QA database were subject to detailed review of the electronic medical record to determine patient comorbidities, initial airway management, phase of detection of aspiration, escalation of care, and sequelae at discharge. The validity of the reports of aspiration events recorded in the QA database however were not subject to scrutiny from 2 additional reviewers like the billing data, as they were directly reported by the pediatric anesthesia team caring for the patient at the time of aspiration.

2.4 | Statistical analysis

The incidence of aspiration was initially calculated using the QA data alone, and then re-calculated after including additional verified aspiration events as identified by the hospital administrative billing records. Confidence intervals for incidence were calculated using a Wilson's score interval. Positive predictive value (PPV) was calculated for the 507.0 (pneumonitis due to inhalation of food or vomitus) ICD-9 code for recognizing (i) aspiration occurring at some point during the hospitalization (including aspiration as a reason for admission) as well as (ii) perioperative aspiration, according to the following formula: true positives/(true positives + false positives).

The records with aspiration as identified by either of the 2 data sources were then evaluated for risk factors using the demographic data from our QA database. Demographic and clinical

variables including age, height, weight, sex, location (operating room or offsite), emergency status, and ASA classification were evaluated to determine the association with an aspiration event. Significant differences in any these variables between children with aspiration and without aspiration were evaluated using *T* tests for continuous variables and chi-square tests for categorical variables. Significance was set at an a priori *P*-value of .05. For each variable, children with missing values were excluded from analysis.

The data analysis for this paper was generated using SAS® software (Version 9.4 of the SAS System for Windows. Copyright © 2013 SAS Institute Inc.).

3. | RESULTS

3.1 | Incidence of aspiration: quality assurance data

A total of 47 272 pediatric anesthetic cases were recorded in our QA database between 2008 and 2014. An aspiration event was reported in 20 cases, yielding an overall incidence of 4.2 in 10 000 anesthetic cases (95% CI: 2.7–6.5 per 10 000 anesthetics) based on the QA data alone.

3.2 | Hospital administrative data review

The hospital administrative discharge data for all patients undergoing a procedure over the same 7-year period were reviewed. A total of 254 hospital admissions records were identified containing 1 of the 2 ICD-9 codes consistent with aspiration: 997.32 (postprocedural aspiration pneumonia) and 507.0 (pneumonitis due to inhalation of food or vomitus). The code 997.32 was only identified in a single record, and the code 507.0 was found in the remaining 253 cases. Based on our record review, 94.5% (*n* = 240) of the hospital records contained evidence of an aspiration event documented in the medical record and 5.5% (*n* = 14) of records had no mention of any aspiration in the medical record.

Of the 240 records containing evidence of an aspiration event, 50% (*n* = 120) represented a condition present at the time of admission or as the primary reason for admission, while 41.2% (*n* = 99) involved aspiration events that occurred outside the perioperative period. The remaining 8.8% (*n* = 21) of records were identified as a possible aspiration event occurring within the perioperative period during initial review. Upon further detailed review, only 9 records (3.5%) were verified as involving likely perioperative aspirations. The remaining 12 records were deemed to be lacking sufficient evidence based on physical exam, radiographic, or bronchoscopic evidence or that it occurred during the immediate perioperative period and was unlikely to be related to the procedure or anesthetic care. Positive predictive value (PPV) for the ICD-9 code 507.0 for recognizing any aspiration during the hospitalization (including aspiration as a reason for admission) was 95%; however, the PPV for specifically recognizing perioperative aspiration using that code was 3.5%.

3.3 | Incidence of aspiration: QA and administrative data

Of the 9 verified perioperative aspirations from the administrative data, 3 records had already been reported in the QA database, but there were 6 cases that had not been captured

by the QA data. The 6 cases identified by the administrative data coupled with the 20 cases identified with the QA yielded a total of 26 cases of aspiration out of 47 272 anesthetics during this 7-year period, or an incidence of aspiration of 5.5 in 10 000 anesthetics (95% CI: 3.7–8.0 per 10 000 anesthetics). The addition of the hospital administrative data provided a 30% increase in cases of aspiration beyond what was captured by the QA data.

3.4 | Comparison of children with and without perioperative aspiration

The characteristics of the patient records with and without documented aspiration during hospital admission are presented in Table 1. Children with aspiration were similar in age, height, weight, sex, location (operating room or offsite), emergency status, and ASA status compared with children with no reported aspiration.

3.5 | Description of children with perioperative aspiration

The 26 children with reported perioperative aspiration are described in Table 2. Of these children, 46% (n = 12) had preexisting neurologic diseases including developmental delay or cerebral palsy and 23% (n = 6) had preexisting cardiac, pulmonary, or gastrointestinal disease. With regard to the timing for the occurrence of aspiration during the perioperative period, 92% (n = 24) could be determined based on the medical record, with a total of 88% (n = 23) of the cases occurring during the intraoperative period, and (4% [n = 1]) occurring in the postanesthesia care unit (PACU). Intraoperative aspiration occurred during induction of anesthesia in 9 children (35%), during maintenance in 10 (38%), and emergence of anesthesia in 4 children (15%), respectively. The distribution of airway management was endotracheal tube (ETT) in 50% (n = 13) of the cases, laryngeal mask airway in 15% (n = 4) of the cases, and general anesthesia without any airway devices in 35% (n = 9) of the cases.

3.6 | Outcomes in children with perioperative aspiration

Among the 26 cases of aspiration, 69% (n = 18) required an escalation of care. Treatment with antibiotics was initiated in 11 children (42%), who received at least 1 dose. Additional airway management was required, including unplanned intubation intra- and postoperatively, in 9 (35%) cases. Of the 12 patients who were scheduled as outpatients, 25% (n = 3) required unplanned hospital admission. Two patients remained intubated postoperatively. There was 1 case in which unplanned ICU admission was required following aspiration. At the time of hospital discharge, no associated mortality or long-term morbidity was identified following perioperative aspiration.

4 | DISCUSSION

Anesthesia-related pulmonary aspiration was found to be a rare event at our pediatric tertiary care center. Our findings of an incidence of 5.5 aspirations in 10 000 cases is within the range of previously published studies and does not differ substantially from rates reported in adults, while employing a comparable sample size.^{1–12} However, the incidence of aspiration described in the present study is double that of the most recent large-scale QA-only audit of pediatric cases, completed in another pediatric tertiary care center in Singapore.⁸ While this discrepancy may be due in part to differences in anesthetic practice between institutions or risk between the 2 populations, underreporting in voluntary QA data likely also played a

role. While other studies have reported the incidence and risk factors of perioperative pulmonary aspiration, the novelty of this study lies in the use of administrative data to supplement the QA data. To our knowledge, there are no pediatric studies of aspiration to date which employ secondary data sources to enhance capture of cases of aspiration, as well as no studies to assess the validity of ICD-9 coding of perioperative aspiration either in children or adults.¹⁹

The large-scale studies of perioperative aspiration to date have been performed in various populations. Three studies were performed in mixed cohorts of adults and children, 2 exclusively in adults, and 6 focused specifically on children. Of these 11 studies, 9 relied exclusively on voluntary reporting methods such as QA databases or surveys given to anesthesiologists to report complications. The most recent study surveyed providers over a focused 2-week study period from 261 centers in Europe, finding the risk of aspiration events to be within the range of previous reports.¹²

Two studies however did include some use of a secondary data source to enhance capture of aspiration events. The first, a study in adults, performed a text search of the hospital wide medical archive recording system for keywords “pulmonary aspiration” and “perioperative” or “postoperative”, ultimately identifying 1 additional case outside of their QA data for an 8% increase in yield.³ The second, a mixed study of adults and children, probed the county inpatient register in Stockholm, Sweden, for all cases of “aspiration pneumonitis” and identified 4 additional cases of aspiration beyond what could be identified using their QA data for a 5% increase in yield.²

The above-described alternative methods of detecting additional cases likely share some of the strengths and limitations of billing data. These studies indicate, however, that their added value for detecting perioperative aspirations over QA is quite small (5–8% increased yield). In our study, the use of hospital administrative billing data combined with chart review identified additional cases of perioperative aspiration resulting in a 30% increase in documented aspiration cases beyond what was recorded in the QA database alone. This demonstrates that a significant portion of aspiration events are likely to be missing from self-reported QA data, and that ICD-9 coded administrative data may be a more effective means for discovering missed cases than other secondary data sources. Furthermore, hospital administrative billing data is almost universally available and can likely be obtained in most hospitals in which QA data research is being performed.

While other ICD-9-coded adverse events have been evaluated, validation of the accuracy of ICD-9 codes for aspiration has not yet been performed.^{19,20} In our population of children who received anesthesia, the positive predictive value (PPV) of the 507.0 (pneumonitis due to inhalation of food or vomitus) ICD-9 code was high (95%) for recognizing aspiration at some point during the hospitalization (including patients with aspiration as a reason for admission). However, when used to identify perioperative aspiration in this cohort, the PPV of the code was low (3.5%). This is not entirely unexpected because that code is not specific to perioperative aspiration. The ICD-9 code specific to perioperative aspiration: 997.32 (postprocedural aspiration pneumonia) was recorded only once during the 7 years surveyed,

and that child was ultimately deemed not to have had a verified perioperative aspiration. As a result, this specific code would not be useful in identifying perioperative aspiration.

Hospital administrative billing data typically includes patients who stay in the hospital for at least 24 hours. Thus, children undergoing outpatient procedures who aspirated but did not demonstrate symptoms requiring further inpatient observation were not recorded in our billing data. Billing data were also unable to detect 7 of the QA-reported inpatient perioperative aspirations, due likely in part to limited documentation of these events. One of these cases, for instance, had been documented only on the QA form and not in any subsequent patient notes. Therefore, aspirations discovered through billing data are more likely to represent events with sequelae recognized by the primary team. These severe complications are important to include in studies of adverse outcomes and some were found to be missed by our QA database.

While we were able to identify additional aspiration events using billing data, there are likely to still be unrecognized perioperative aspiration events. This can occur for a number of reasons including the lack of diagnosis while the patient was still in the hospital, the lack of adequate documentation by providers, or lack of recognition by the coder entering the ICD-9 code into the billing records. For example, though all children with the codes for pneumonitis due to the inhalation of food/vomitus and postprocedural aspiration pneumonia were reviewed, it is possible that aspirations could be misclassified as other conditions such as pneumonia or not coded at all.

While over 250 records needed to be reviewed to identify an additional 6 patients with aspiration, changes to hospital billing may improve the efficiency of this method as hospital billing begins to include variables indicating whether certain conditions were “present on admission” (POA).²¹ The capability to remove cases of aspiration based on POA status would reduce the record review by 50%, as demonstrated by findings at our institution. Hospital billing in the United States has also recently switched to ICD-10 codes on October 1, 2015.²² As medical billing and coding specialists gain experience in using ICD-10 codes, the accuracy of hospital billing data may also change. For example, ICD-10 has a code specifically for anesthesia-related aspiration: (J95.4: Chemical pneumonitis due to anesthesia).

In prior studies, several risk factors have been identified as being associated with perioperative pulmonary aspiration including higher ASA status, younger age, and emergent surgery.^{1,4,7,8,11} Such associations were not found in the present study. Since perioperative aspiration is an extremely rare event and may depend on the patient populations studied as well as the clinical practice at each institution, it is possible that risk factors may vary between centers, complicating the prediction of aspiration risk. For example, aspiration was noted in our study to occur with equal likelihood during induction as during maintenance, which is in contrast to prior findings regarding timing.^{1,8,12} In comparing our outcome with previously published findings from years ago, it should also be noted that practices and medications have changed substantially over the past several decades.

In patients with confirmed aspiration, escalation of care included treatment with antibiotics, unplanned intubation intra- or postoperatively, increased length of stay for outpatients, and ICU transfer. Treatment with antibiotics and/or unplanned intraoperative intubation was the most common care escalations, with 31% of patients having no documented escalation of care. None of the patients in whom aspiration occurred were noted to have any long-term sequelae or to have suffered mortality at discharge, and this is largely consistent with the published literature to date.²³

While ICD-9 codes for aspiration cannot be used to independently identify perioperative aspiration events, by employing expert review in combination with these codes, we were able to significantly increase the number of aspiration events identified beyond those recorded in our departmental QA database. This finding underscores the fact that many adverse events are likely missed by voluntary reporting methods and that secondary data sources are effective in identifying additional events. Though large-scale QA databases are still valuable for studying rare perioperative outcomes when no other data source is available, it is important to recognize that adverse outcomes are likely to occur at a significantly higher rate than is reported by such studies.

ACKNOWLEDGMENTS

We acknowledge the Tripartite Request Assessment Committee (TRAC) of New York-Presbyterian Hospital and Columbia University Medical Center for their help in obtaining the hospital administrative billing records used in this study.

Funding information

Dr. Caleb Ing is supported by a Herbert Irving Scholars Award as well as the Agency for Healthcare Research and Quality (AHRQ) under award number K08HS022941. The content is solely the responsibility of the authors and does not necessarily represent the official views of the AHRQ.

REFERENCES

1. Kluger MT, Short TG. Aspiration during anaesthesia: a review of 133 cases from the Australian Anaesthetic Incident Monitoring Study (AIMS). *Anaesthesia* 1999;54:19–26. [PubMed: 10209365]
2. Olsson GL, Hallen B, Hambraeus-Jonzon K. Aspiration during anaesthesia: a computer-aided study of 185,358 anaesthetics. *Acta Anaesthesiol Scand* 1986;30:84–92. [PubMed: 3754372]
3. Sakai T, Planinsic RM, Quinlan JJ, Handley LJ, Kim TY, Hilmi IA. The incidence and outcome of perioperative pulmonary aspiration in a university hospital: a 4-year retrospective analysis. *Anesth Analg* 2006;103:941–947. [PubMed: 17000809]
4. Warner MA, Warner ME, Weber JG. Clinical significance of pulmonary aspiration during the perioperative period. *Anesthesiology* 1993;78:56–62. [PubMed: 8424572]
5. Mellin-Olsen J, Fasting S, Gisvold SE. Routine preoperative gastric emptying is seldom indicated. A study of 85,594 anaesthetics with special focus on aspiration pneumonia. *Acta Anaesthesiol Scand* 1996;40:1184–1188. [PubMed: 8986180]
6. Beach ML, Cohen DM, Gallagher SM, Cravero JP. Major adverse events and relationship to nil per OS status in pediatric sedation/ anesthesia outside the operating room: a report of the pediatric sedation research consortium. *Anesthesiology* 2016;124:80–88. [PubMed: 26551974]
7. Borland LM, Sereika SM, Woelfel SK, et al. Pulmonary aspiration in pediatric patients during general anesthesia: incidence and outcome. *J Clin Anesth* 1998;10:95–102. [PubMed: 9524892]
8. Tan Z, Lee SY. Pulmonary aspiration under GA: a 13-year audit in a tertiary pediatric unit. *Pediatr Anesth* 2016;26:547–552.

9. Tiret L, Desmonts JM, Hatton F, Vourc'h G. Complications associated with anaesthesia—a prospective survey in France. *Can Anaesth Soc J* 1986;33:336–344. [PubMed: 3719435]
10. Walker RW. Pulmonary aspiration in pediatric anesthetic practice in the UK: a prospective survey of specialist pediatric centers over a one-year period. *Pediatr Anesth* 2013;8:702–711.
11. Warner MA, Warner ME, Warner DO, Warner LO, Warner EJ. Perioperative pulmonary aspiration in infants and children. *Anesthesiology* 1999;90:66–71. [PubMed: 9915314]
12. Habre WDN, Virag K, Becke K, et al. Incidence of severe critical events in paediatric anaesthesia (APRICOT): a prospective multicentre observational study in 261 hospitals in Europe. *Lancet Respir Med* 2017;5:412–425. [PubMed: 28363725]
13. Benson MJA, Fuchs C, Quinzio L, et al. Using an anesthesia information management system to prove a deficit in voluntary reporting of adverse events in a quality assurance program. *J Clin Monit Comput* 2000;16:211–217. [PubMed: 12578105]
14. Dindo D, Hahnloser D, Clavien PA. Quality assessment in surgery: riding a lame horse. *Ann Surg* 2010;251:766–771. [PubMed: 20224375]
15. Sanborn KVCJ, Kuroda M, Thys DM Detection of intraoperative incidents by electronic scanning of computerized anesthesia records. Comparison with voluntary reporting. *Anesthesiology* 1996;85:977–987. [PubMed: 8916813]
16. Simpao AFPE, Cook-Sather SD, Gurnaney HG, Rehman MA The reliability of manual reporting of clinical events in an anesthesia information management system (AIMS). *J Clin Monit Comput* 2012;26: 437–439. [PubMed: 22618299]
17. Kakavouli ALG, Carson MP, Sobol J, et al. Intraoperative reported adverse events in children. *Pediatr Anesth* 2009;19:732–739.
18. O'Malley KJ, Cook KF, Price MD, Wildes KR, Hurdle JF, Ashton CM. Measuring diagnoses: ICD code accuracy. *Health Serv Res* 2005;40: 1620–1639. [PubMed: 16178999]
19. Pinyavat TRH, Lang BH, Wong CA, et al. Accuracy of malignant hyperthermia diagnoses in hospital discharge records. *Anesthesiology* 2015;122:55–63. [PubMed: 25272246]
20. Walsh KECS, Foy S, Baker MA, et al. Validation of anaphylaxis in the Food and Drug Administration's Mini-Sentinel. *Pharmacoepidemiol Drug Saf* 2013;22:1205–1213. [PubMed: 24038742]
21. Present on Admission (POA) Indicator MLN Matters, 2013 www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNMattersArticles/downloads/MM5499.pdf. Accessed August 29, 2017.
22. ICD-10. Centers for Medicare and Medicaid Services, 2017 www.cms.gov/medicare/coding/icd10/index.html. Accessed August 29, 2017.
23. Kelly CJWR Perioperative pulmonary aspiration is infrequent and low risk in pediatric anesthetic practice. *Pediatr Anesth* 2015;25: 36–43.

What is already known

- Perioperative aspiration is a rare but potentially devastating complication of anesthesia, with studies of rates and risk factors in children based exclusively on quality assurance databases.
- Quality assurance databases and other voluntary-reported sources likely underestimate hospital complications.
- Secondary data sources have been used with limited efficacy to improve upon voluntary reporting-based studies of aspiration; International Classification of Diseases, Ninth Revision Clinical Modification (ICD-9) coded administrative billing data have not been utilized.

What this article adds

- The positive predictive value (PPV) of ICD-9 codes in administrative billing data to identify any cases of aspiration was 94.5% overall, but only 3.5% for aspiration specific to the perioperative period.
- Upon expert review of the patients identified through administrative data, we found that quality assurance data underestimated the rate of perioperative aspiration at our institution by at least 30%.

TABLE 1

Risk factors for perioperative pulmonary aspiration

	No Aspiration (n = 47 246)	Aspiration (n = 26)	P-value
Age (year) ^a	6.87 ± 5.4	7.05 ± 4.6	.8
Height (cm) ^a	114.18 ± 43.6	115.33 ± 28.8	.8
Weight (kg) ^a	27.15 ± 22.1	28.99 ± 20.7	.67
Sex			
Male	27 081 (57%)	14 (54%)	.7
Female	20 144 (43%)	12 (46%)	
(Missing)	21 (0.04%)	0 (0%)	
Location			
OR	28 229 (60%)	13 (50%)	.17
Offsite	16 598 (35%)	13 (50%)	
Emergency status			
Emergent	5668 (12%)	1 (4%)	.18
Elective	40 054 (85%)	25 (96%)	
(Missing)	1524 (3%)	0 (0%)	
ASA status			
1	10 087 (21%)	2 (8%)	.1
2	16 918 (36%)	8 (31%)	
3 or greater	20 191 (43%)	16 (62%)	
(Missing)	50 (0.1%)	0 (0%)	

Location = Location where procedure performed; ASA Status = American Society of Anesthesiology Physical Status Classification.

^aThe values are means ± SD.

TABLE 2

Descriptive data for aspiration episodes

Data (n)	Age, year	Sex	ASA	Comorbidities	Procedure	Initial airway	Timing	Disposition
QA data (17)	15.8	F	1	None	Arthroscopic knee surgery	Natural airway	Unknown	Outpatient as planned
	3.8	F	3	Asthma, heart surgery	Scoliosis surgery	ETT	Induction	ICU admit as planned
	2.8	F	3	Obstructive sleep apnea, heart transplant	Supraglottoplasty	Natural airway ^a	Maintenance	ICU admit as planned ^b
	10.9	F	3	Asthma, developmental delay, heart transplant	Cardiac catheterization	ETT	Induction	Floor admit as planned, antibiotic
	3.2	M	2	Hypotonia, developmental delay, failure to thrive	MRI	Laryngeal mask airway ^a	Maintenance	Floor admit, unplanned
	3.8	F	2	Developmental delay, cerebral palsy	Tendon lengthening	ETT	Induction	Outpatient as planned
	12.5	M	3	Leukemia, gastroesophageal reflux	Bilateral orchiectomy	ETT	Emergence	Outpatient as planned
	6.7	M	2	Developmental delay	MRI	Natural airway ^a	Maintenance	Outpatient as planned
	10.6	M	3	Myelomeningocele, contractures	Right lower extremity osteotomy	ETT	Induction	Floor admit as planned
	1.8	F	3	Wilm's tumor	MRI	Laryngeal mask airway ^a	Maintenance	Outpatient as planned
	2.8	M	1	None	Tonsil and adenoidectomy	ETT	Emergence	Floor admit as planned
	0.2	F	3	Hypoparastalsis (Berdon's syndrome)	Jejunostomy revision	ETT	Induction	ICU admit as planned, antibiotic
	3.2	M	3	Brain tumor	MRI	Natural airway ^a	Maintenance	Outpatient as planned
	11.5	F	2	Anxiety, gastroesophageal reflux disease	Upper Endoscopy	Natural airway ^a	Induction	Outpatient as planned
	3.2	M	3	Leukemia, microcephaly	LP with chemo	Natural airway	Emergence	Outpatient as planned
	7.5	M	2	Developmental delay	Frenulotomy	ETT	Induction	Outpatient as planned
	8.3	M	3	Attention deficit disorder, anxiety, leukemia	LP, bone marrow biopsy	Laryngeal mask airway ^a	Maintenance	Floor admit as planned
Both sources (3)	7.8	F	3	Prior heart surgery	Cardiac catheterization	ETT	Emergence	ICU admit as planned, antibiotic
	17.2	M	2	Developmental delay, anxiety, prior heart surgery	Tendon lengthening	ETT	Maintenance	Floor admit as planned, antibiotic
	8.2	F	3	Prior small bowel and colonic transplant	Upper Endoscopy	Natural airway ^a	Maintenance	Floor admit as planned, antibiotic
Billing data (6)	13.2	F	3	Leukemia with CNS involvement	LP, bone marrow biopsy	Natural airway	Maintenance	Floor admit as planned, antibiotic

Data (n)	Age, year	Sex	ASA	Comorbidities	Procedure	Initial airway	Timing	Disposition
	3.4	F	3	Prior heart transplant	Cardiac catheterization	ETT	PACU	ICU admit, unplanned, antibiotic ^b
	3.2	M	3	Developmental delay, gastrostomy tube	Gastrostomy tube exchange	ETT	Induction	Floor admit, unplanned, antibiotic
	5	M	2	Lymphoma	Central line removal	ETT	Induction	Floor admit, unplanned, antibiotic
	10.8	M	2	Asthma	Upper Endoscopy	Natural airway	Unknown	Floor admit as planned, antibiotic
	5.4	M	3	Leukemia	LP	Laryngeal mask airway	Maintenance	Floor admit as planned, antibiotic

LP = Lumbar puncture; Unknown = Cases of aspiration in which the timing could not be determined by chart review.

^aIndicates patient required intraoperative airway management with an ETT following aspiration (extubation upon completion of procedure).

^bIndicates patient required postoperative airway management with an ETT following aspiration.