ANESTHESIOLOGY

Pulmonary Aspiration of Gastric Contents: A Closed Claims Analysis

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EDITOR'S PERSPECTIVE

What We Already Know about This Topic

- Perioperative pulmonary aspiration of gastric contents has been, and continues to be, associated with severe morbidity and death in spite of recent advances in relevant guidelines and airway management

What This Article Tells Us That Is New

- In a closed claims analysis of 115 cases of pulmonary aspiration, death occurred in 57% of the claims and severe permanent injury in another 14%
- Sixty-one percent of the patients in the claims had either gastrointestinal obstruction or another intraabdominal process
- Anesthetic practice was judged to be substandard in 59% of the 115 claims

ABSTRACT

Background: Perioperative pulmonary aspiration of gastric contents has been associated with severe morbidity and death. The primary aim of this study was to identify outcomes and patient and process of care risk factors associated with gastric aspiration claims in the Anesthesia Closed Claims Project. The secondary aim was to assess these claims for appropriateness of care. The hypothesis was that these data could suggest opportunities to reduce either the risk or severity of perioperative pulmonary aspiration.

Methods: Inclusion criteria were anesthesia malpractice claims in the American Society of Anesthesiologists Closed Claims Project that were associated with surgical, procedural, or obstetric anesthesia care with the year of the aspiration event 2000 to 2014. Claims involving pulmonary aspiration were identified and assessed for patient and process factors that may have contributed to the aspiration event and outcome. The standard of care was assessed for each claim.

Results: Aspiration of gastric contents accounted for 115 of the 2,496 (5%) claims in the American Society of Anesthesiologists Closed Claims Project that met inclusion criteria. Death directly related to pulmonary aspiration occurred in 66 of the 115 (57%) aspiration claims. Another 16 of the 115 (14%) claims documented permanent severe injury. Seventy of the 115 (61%) patients who aspirated had either gastrointestinal obstruction or another acute intraabdominal process. Anesthetic management was judged to be substandard in 62 of the 115 (59%) claims.

Conclusions: Death and permanent severe injury were common outcomes of perioperative pulmonary aspiration of gastric contents in this series of closed anesthesia malpractice claims. The majority of the patients who aspirated had either gastrointestinal obstruction or acute intraabdominal processes. Anesthesia care was frequently judged to be substandard. These findings suggest that clinical practice modifications to preoperative assessment and anesthetic management of patients at risk for pulmonary aspiration may lead to improvement of their perioperative outcomes.

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Perioperative pulmonary aspiration of gastric contents has been a major patient safety issue. Although there are studies to suggest that the incidence of pulmonary aspiration may have decreased in the past two decades, its potential to cause severe morbidity and death appears to remain high despite interventions such as practice guidelines for fasting, difficult airway algorithms, improved airway equipment, and general education efforts directed at anesthesia professionals about risk factors for this potentially catastrophic perioperative event.[1–6]

We used the Anesthesia Closed Claims database to identify claims that involved perioperative pulmonary aspiration of gastric contents. The primary aim of this study was to identify outcomes and patient and process of care risk factors associated with gastric aspiration claims in the database. The secondary aim was to assess these claims for appropriateness of care. The hypothesis was that these data could suggest opportunities to reduce either the risk or severity of perioperative pulmonary aspiration.

Materials and Methods

The Anesthesia Closed Claims Project database is a structured collection of closed anesthesia malpractice claims in the United States. Detailed study methods have been previously described.[7] The University of Washington Institutional

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Review Board (Seattle, Washington) determined that retrospective review of Anesthesia Closed Claims Project data does not involve human subjects and is exempt (Study 00009904). Throughout the duration of the Closed Claims Project, data have been collected from malpractice insurers throughout the United States and abstracted from insurance company files by practicing anesthesiologists. Sources have included depositions, medical records, autopsy reports, expert witness statements, claims manager summaries, consultant evaluations, and other legal documents. The data abstracted have included the type of surgery, details of the anesthesia care provided, patient demographics, patient outcomes, legal proceedings, and any payments made. Trained on-site anesthesiologist reviewers have evaluated the type and severity of injury and the cause of injury (*i.e.*, damaging event). Severity of patient injury in each claim has been determined using the National Association of Insurance Commissioners' (Kansas City, Missouri) 10-point scale, which ranges in severity from 0 to 5 (temporary or minor injury) to 6 to 8 (permanent severe injury) to 9 (death).[8] On-site anesthesiologist reviewers have written narrative summaries of each claim, describing the sequence of events and potential causes of injury and providing additional details specific to that claim that have not otherwise been captured on data collection forms.

Inclusion criteria for this study were anesthesia malpractice claims associated with surgical, procedural, or obstetric anesthesia care for adverse events that occurred during the period of 2000 to 2014 in the Anesthesia Closed Claims Project database. Claims associated with acute or chronic pain management were not included.

Definition of Variables

Claims in which pulmonary aspiration with gastric contents as the aspirated material was identified as a primary or secondary damaging event were categorized as aspiration of gastric contents ("aspiration"). Claims in which the aspirated material was composed of something else (*e.g.*, blood, teeth, dental appliances [n = 9]) were not included in the aspiration group used for this study. Claims with unsubstantiated allegations of aspiration (n = 4) were also not included in the aspiration group.

We classified the variables and planned the qualitative analysis of clinical factors relevant to aspiration of gastric contents before accessing the data. Clinical details of aspiration were independently abstracted from claim narratives (K.L.M., K.B.D., M.E.W., M.A.W.) using a Research Electronic Data Capture (REDCap) survey. Clinical details queried in the survey included the timing of the aspiration event, the composition of the anesthesia care team at the time of the aspiration event, clinical risk factors for pulmonary aspiration of gastric contents, and clinical care issues in the claim. Timing of the aspiration event was classified as preinduction, during regional anesthesia or monitored anesthesia care, during induction of general anesthesia, during maintenance of general anesthesia, during emergence and tracheal extubation, during phase 1 recovery, or postoperatively. Induction of general anesthesia was further subclassified as before airway instrumentation *versus* during airway instrumentation. Preinduction included events that occurred in the surgical suite, including preoperative preparation areas, during sedation before entry to the operating room, during transport to the operating room, or during positioning in the operating room before induction anesthesia. Phase 1 recovery included transport from the operating room after the procedure ended or within a postanesthesia care or intensive care unit within 1 h of the procedure's end. Postoperative events included events that occurred on a ward or within an intensive care unit after the end of phase 1 recovery. For cases in which aspiration occurred during induction of general anesthesia, we identified whether rapid sequence induction was explicitly mentioned in the claim narrative and whether cricoid pressure was noted as being applied before the aspiration event.

The composition of the clinical care team was classified according to the presence and availability of anesthesia professionals at the time of the aspiration event. Classifications were (1) no anesthesia professional involved in the patient's care; (2) only one anesthesia professional involved with the patient at the time of aspiration and no statement that another may have been available; (3) only one anesthesia professional involved with the patient and a statement that another may or could have been available; or (4) more than one anesthesia professional involved with the patient at the time of aspiration event.

Clinical risk factors included emergency procedures, major trauma (procedure for traumatic injury performed on an emergency basis or within 48 h of a major trauma event), gastrointestinal obstruction, other acute intraabdominal processes, obesity with body mass index greater than or equal to 35, recent oral intake (less than 6 h before procedure or more than 8 h if the meal was fatty, excluding medications or clear liquids less than 2 h before anesthesia), recent opioid administration, treatment for gastroesophageal reflux disease, treatment for diabetes, previous gastric bypass or sleeve, history of neurologic disease (stroke, depressed consciousness, neurologic condition that may impair oropharyngeal coordination such as Parkinson disease), and current pregnancy. Other risk factors identified from the narrative were also abstracted. Any risk factor identified by at least two of the authors (K.L.M., K.B.D., M.E.W., M.A.W., K.L.P.) was classified as present.

Clinical care issues included nonplacement of a nasogastric tube before the aspiration event, poor clinical management of the aspiration event, or difficult intubation (more than three attempts). Additional clinical care issues were evaluated for subsets of relevant aspiration claims. Use of a supraglottic airway or mask in a patient at risk for aspiration was evaluated for all claims except aspiration preinduction, during regional anesthesia or monitored anesthesia

care, or postoperatively. Excessive sedation during regional anesthesia or monitored anesthesia care, or before general anesthesia, was evaluated for all claims except for aspiration during or after induction of general anesthesia. Lack of cricoid pressure was evaluated only if aspiration occurred during induction of general anesthesia. Premature extubation was evaluated only if aspiration occurred at extubation or during phase 1 recovery. Agreement by two of the authors (K.B.D., M.E.W., M.A.W.) and acceptable interrater reliability (κ greater than 0.40) between author pairs were required to classify a clinical care issue as present in the claim.

Appropriateness of care was assessed by the on-site reviewer as appropriate (based on reasonable or prudent practice at the time of the event), substandard, or impossible to judge, and reviewed by the Anesthesia Closed Claims Project investigators for final assessment. The reliability of these evaluations has been judged acceptable.[9] Anesthesia payments included payments made on behalf of anesthesiologists and anesthesia corporations. Payments on behalf of nurse anesthetists or other defendants were not included. Payments were adjusted to 2019 dollar amounts using the Consumer Price Index.[10]

Statistical Analysis

The sample size was based on available data; no *a priori* power analysis was conducted. The analysis plan for this study was made before accessing the data. Interrater reliability was determined on a sample of aspiration claims for each clinical care issue using κ scores. Pairwise κ scores between the three practicing anesthesiologist authors (K.B.D., M.E.W., M.A.W.) were calculated and the mean of the three pairwise scores reported. Median and interquartile range were reported for payments because they were not normally distributed. Claims with no payment or missing payment data were excluded from calculation of median and interquartile range. All statistical analysis employed IBM SPSS Statistics 24 and 26 (IBM Corporation, USA).

Results

Aspiration of gastric contents accounted for 115 of 2,492 (5%) claims in the American Society of Anesthesiologists (Schaumburg, Illinois) Closed Claims Project database that met inclusion criteria, with adverse events occurring from 2000 to 2013. There were no aspiration-associated claims in 2014. Patient characteristics and anesthesia and procedure types are shown in table 1. Sixty-six of 115 (57%) patients who aspirated were judged to have died as a consequence of their aspiration event, and another 16 (14%) had a permanent severe injury (table 2). Anesthesia care was assessed as substandard in 62 of the 105 (59%) claims in which an assessment was made (table 2). It was not possible to judge the anesthesia care in the remaining 10 claims. Anesthesia payments were made in 67 of 114 (59%) of the claims

Table 1. Patient Characteristics and Anesthesia and Procedure Types for Pulmonary Aspiration

	Aspiration Claims, No. (%)*
Patient characteristics	
Male	64 (56)
Obese (n = 89)	48 (54)
American Society of Anesthesiologists Physical Status III–V (n = 114)	69 (61)
Emergency status (n = 114)	52 (46)
Trauma patient	11 (10)
Age, mean ± SD	51 ± 19
Patient age < 17 yr	5 (4)
Inpatient procedure (n = 113)	95 (84)
Primary anesthetic	
General anesthesia	92 (80)
Monitored anesthesia care	17 (15)
Regional anesthesia	4 (3)
Other anesthesia†	2 (2)
Type of procedure	
Laparotomy	33 (29)
Endoscopy	12 (10)
Other abdominal procedures‡	21 (18)
Obstetric procedures	3 (3)
All other nonabdominal procedures	46 (40)

*n = 115 aspiration claims, unless otherwise noted in parentheses; claims with missing data were excluded from calculation of descriptive statistics. †Including claims with no anesthetic provided, claims with both general and regional anesthetic, and claims of oral medications and sedation. ‡Including hernia repairs, cholecystectomies, gastric bypass procedures, appendectomies, and other abdominal laparoscopic procedures.

Table 2. Patient Outcomes and Claim Liability for Pulmonary Aspiration

	Aspiration Claims, No. (%)*
Patient outcomes†	
Death	66 (57)
Any permanent severe injury	16 (14)
Only temporary or minor injury	33 (29)
Claim liability	
Appropriateness of care (n = 105)	
Substandard care	62 (59)
Appropriate care	43 (37)
Payments	
Anesthesia payment was made (n = 114)	67 (59)
Median payment (n = 67)‡	$347,500
25% quartile	$127,600
75% quartile	$1,042,500

*n = 115 aspiration claims, unless otherwise noted in parentheses; claims with missing data were excluded from calculation of descriptive statistics. †Severity of patient injury in each claim has been determined using the National Association of Insurance Commissioners' (Kansas City, Missouri) 10-point scale, which ranges in severity from 0 to 5 (temporary or minor injury) to 6 to 8 (permanent severe injury) to 9 (death).[8] ‡Median payments (2019 adjusted dollars) include payments by anesthesiologists and anesthesia corporations. Claims with no payment (n = 47) and claims with missing payment data (n = 1) were excluded from calculation of descriptive statistics.

with available data and had a median payment of $347,500 (interquartile range, $127,600 to $1,042,500; table 2).

Risk Factors for Pulmonary Aspiration of Gastric Contents

At least one risk factor for aspiration was identified in 107 of 115 (93%) claims of pulmonary aspiration (table 3). The most common risk factors in the 115 claims were emergency procedures (52 [45%]) and gastrointestinal obstruction (41 [36%]) or some other acute intraabdominal process (29 [25%]). Eighty-eight of 115 (77%) patients had more than one risk factor present. Other common risk factors identified in 10% or more of claims were gastroesophageal reflux disease, obesity with body mass index greater than 35, and diabetes (table 3). However, these risks factors were most often in combination with others. For instance, gastroesophageal reflux was the only risk factor in just four patients, obesity was the only risk factor in three patients, and diabetes was the only risk factor in one patient. In five patients, the patients had both gastroesophageal reflux and diabetes without other risk factors.

Recent oral intake (less than 6 h before the procedure or more than 8 h if the meal was fatty, excluding medications with small quantities of clear liquids) occurred in 17 of 115 (15%) claims. Of the patients with recent oral intake, only two patients did not have other risk factors. One patient without other risk factors vomited with externally applied abdominal pressure during a colonoscopy performed after having clear liquids up to 2 h before the procedure. The other patient without other risk factors denied oral intake, but in fact had ingested cookies and large quantities of clear liquids within 4 h of surgery. There were no aspiration claims associated with protein and carbohydrate drinks 2 h before surgery. Eight patients with recent oral intake had gastrointestinal obstruction or acute intraabdominal processes, and two patients had acute trauma. Only 4 of 115 (3%) claims involved pregnant patients. Three of these patients were undergoing cesarean deliveries. Of these three, only one involved general anesthesia. The fourth pregnant patient aspirated during a cerclage procedure, and an emergency cesarean delivery was performed with general anesthesia. All other risk factors are listed in table 3.

Table 3. Risk Factors for Aspiration of Gastric Contents

Risk Factor	No. (%)*
Emergency procedure	52 (45)
Gastrointestinal obstruction	41 (36)
Other acute intraabdominal process†	29 (25)
Morbid obesity	25 (22)
Gastroesophageal reflux disease	22 (19)
Diabetes mellitus	18 (16)
Recent oral intake‡	17 (15)
Recent opioid administration	10 (9)
Major trauma§	9 (8)
Previous gastric bypass or sleeve	9 (8)
Neurologic disease‖	6 (5)
Pregnancy	4 (3)
Other#	2 (2)
Any risk factor present	107 (93)

*n = 115. †Excludes gastrointestinal obstruction; other acute intraabdominal processes included perforated viscus (n = 7) or ileus (n = 7), acute cholecystitis (n = 5), appendicitis (n = 3), intraabdominal hematoma (n = 2), ischemic bowel (n = 2), ascites (n = 1), eviscerated bowel (n = 1), and upper gastrointestinal bleeding (n = 1). ‡Oral intake, excluding medications, < 6 h before procedure or < 8 h if the meal was fatty; §procedure was performed on an emergency basis or within 48 h of a major trauma event; ‖stroke, depressed consciousness, or other neurologic conditions that may impair oropharyngeal coordination; #other risk factors included colon interposition for esophageal fistula and esophageal achalasia (n = 1 each).

Phase of Care and Clinical Management

While aspiration most commonly occurred during induction of general anesthesia (55 of 115 claims [48%]), this event also occurred at other times throughout the anesthetic course (table 4). Ninety-two of the 115 (80%) claims involved general anesthesia. Of these 92 claims involving general anesthesia, aspiration occurred during induction of general anesthesia in 55 (60%) claims. Of these 55 claims involving aspiration during induction of general anesthesia, it was not possible to determine exactly when aspiration occurred (*e.g.*, before or during airway manipulation) in 21 (38%) of the claims. Of the remaining 34 claims, the on-site anesthesiologist reviewers judged that aspiration occurred during induction of anesthesia and before airway instrumentation in 23 (68%) claims and during airway instrumentation in 11 (32%) claims.

Endotracheal intubation was performed in 49 of 55 (89%) claims in which aspiration occurred during induction of general anesthesia. The other airway management techniques used in claims that involved aspiration during induction of general anesthesia included supraglottic airways (n = 5) and mask ventilation (n = 1). Ten of 49 (20%) claims that involved endotracheal intubation during induction of general anesthesia were judged

Table 4. Phase of Care when Pulmonary Aspiration Occurred

Phase	No. (%)*
Preinduction	4 (3)
During regional anesthesia	4 (3)
During monitored anesthesia care	17 (15)
During induction of general anesthesia	
Before airway instrumentation	23 (20)
During airway instrumentation	11 (10)
Timing unknown	21 (18)
During maintenance of general anesthesia	12 (10)
During emergence and tracheal extubation	8 (7)
Phase 1 recovery (includes transport)	4 (3)
Postoperative	6 (5)
Unknown	5 (4)

See Materials and Methods section for definitions of phases of care.
*Percentages do not sum to 100% due to rounding.

by on-site anesthesiologist reviewers to involve difficult intubations (more than three attempts). The use of rapid sequence induction was explicitly noted in the narrative for 28 of 49 (57%) claims that included endotracheal intubation during induction of general anesthesia. Cricoid pressure was applied before the aspiration event in 22 of those 49 (45%) claims and was specifically not applied in 19 (39%). It is not known if cricoid pressure was applied in the remaining 8 of 49 (16%) claims that occurred during induction of general anesthesia and endotracheal intubation. The on-site anesthesiologist reviewers judged that lack of use of cricoid pressure during induction of general anesthesia in 15 of 49 (31%) claims involving endotracheal intubation contributed to the aspiration events.

Fourteen of the 92 (15%) claims involving general anesthesia occurred in patients in whom a supraglottic airway was used. Mask ventilation only was used in 3 of 92 (3%) claims involving general anesthesia.

Of the five pediatric cases, one was a trauma patient who ate 1 to 2 h before the trauma and aspirated during anesthesia with a supraglottic airway. Two pediatric patients aspirated upon emergence from anesthesia. The remaining two pediatric patients aspirated postoperatively after discharge from the postanesthesia care unit: one at home after a large meal and one on the ward.

Only one anesthesia professional was involved with the patient at the time of aspiration in 91 of 115 (79%) claims. In 16 of those 91 (18%) cases, only one anesthesia professional was involved, but there was a statement that another may or could have been available. In 12 of 115 (10%) claims, more than one anesthesia professional was involved with the patient at the time of aspiration.

Clinical care issues were identified in 89 of 115 (77%) aspiration claims (table 5). Overall, the most common issue identified was failure to place a nasogastric tube before the aspiration event in 36 of 115 (31%) claims. The authors were not able to determine how many of the 115 patients had risk factors that indicated the patient may have benefited from preoperative placement of a nasogastric tube and reduction of gastric content. However, only 36 of 70 (51%) patients who had documented gastrointestinal obstruction or other acute intraabdominal processes had evidence that a nasogastric tube was in place immediately before their procedures. More than three attempts at endotracheal intubation occurred in 10 of 115 (9%) claims. Nine of the 18 (50%) patients who aspirated at extubation or during phase 1 recovery were judged to have been extubated prematurely, leading to pulmonary aspiration. Seventeen of 115 (15%) claims involved monitored anesthesia care, and 4 of 115 (3%) claims involved regional anesthesia. Management of the aspiration event was judged as substandard in 62 of 115 (59%) claims.

Discussion

In this series of closed claims cases, more than two of every three patients who experienced perioperative aspiration of gastric contents died or suffered permanent severe injury as a direct consequence of it. Currently, there are no specific treatment interventions for perioperative aspiration of gastric contents other than supportive care and management of aspiration sequelae. Therefore, it remains an important patient safety issue that demands our continued efforts to preemptively identify risk factors for every patient receiving sedation and anesthetic care and appropriately introduce clinical practices to better identify and mitigate the risk of perioperative pulmonary aspiration.

There are a number of risk factors that have often been reported for perioperative pulmonary aspiration of gastric contents.[1–6] These factors have included emergency procedures, gastrointestinal obstruction or some other acute intraabdominal process, gastroesophageal reflux disease, diabetes, and recent oral intake. The great majority (93%) of patients in this closed claims study had one or more of these risk factors for aspiration, and many were, or could have been, readily identified preoperatively. Although pregnancy and delivery have historically been considered major risk factors for perioperative pulmonary aspiration, it is worth noting that only 4 of 115 (3%) patients in this series were pregnant. The increase in the use of regional anesthesia for women undergoing cesarean section procedures during the past two decades has been associated with the decline of pulmonary aspiration.[11–13]

Unfortunately, there is a paucity of specific data on each of the risk factors often associated with perioperative pulmonary aspiration. In general, it is not clear that each of the commonly described factors were associated with an increased risk of pulmonary aspiration during the study period. For

Table 5. Clinical Care Issues in Aspiration Claims

Issue	n*	Total Aspiration Claims, %†	Mean Paired κ
Nasogastric tube not placed before aspiration event	36	31	0.631
Poor management of aspiration event	31	27	0.727
Use of supraglottic airway or mask in patient at risk for aspiration (N = 81)‡	17	15	0.910
Excessive sedation during regional anesthesia, monitored anesthesia care, or before general anesthesia (N = 30)§	16	14	0.604
Lack of cricoid pressure (N = 55)‖	15	13	0.632
Difficult intubation#	10	9	0.648**
Premature extubation (N = 18)††	9	8	0.576

*n = number of claims included in evaluation; agreement by two of the authors plus acceptable interrater reliability (κ > 0.40) between author pairs were required to classify a clinical care issue as present in the claim. †N = 115, unless otherwise noted. ‡Excluded aspiration preinduction, during regional anesthesia or monitored anesthesia care, or postoperatively. §Excluded aspiration during or after induction of general anesthesia. ‖Included only aspiration at induction of general anesthesia. #Difficult intubation was defined as > 3 attempts. **κ between two authors only. One author did not identify this issue in any claim, so paired κ values for that author could not be calculated. ††Included only aspiration that occurred at extubation or during phase 1 recovery.

example, changes in practice during the last two decades such as better management of diabetes and gastroesophageal reflux may have reduced or eliminated any negative impact of these factors on pulmonary aspiration. Therefore, anesthesia professionals must use their judgment in determining how to best modify their anesthetic practices for each patient. These modifications may include airway and gastric content assessments, airway management techniques, the presence or absence of trained personnel who may assist with airway management of patients who have factors that suggest increased risk for aspiration, and others.

More than 60% of the patients who aspirated in this series had either gastrointestinal obstruction or acute intraabdominal processes. This finding supports practice modifications that identify before induction of anesthesia the presence of obstruction or acute intraabdominal processes and prompt preoperative intervention to reduce gastric content volume in those who have elevated preinduction volumes. When it is not clear if a patient has a high volume of gastric content preoperatively, ultrasound imaging has been shown to be easy to learn and perform and provides reasonably good estimates of gastric content volumes.[14–16] Its use may provide information that modifies preoperative preparation of individuals who have high volumes (*e.g.*, nasogastric decompression), subsequent airway management, and decisions on whether to seek additional assistance.

Regarding airway management, it is not clear in the findings of this study if the use of a rapid sequence induction and cricoid pressure played roles in either decreasing or increasing the risk of pulmonary aspiration during induction of general anesthesia. Of the 49 claims in this study that involved aspiration of gastric contents that occurred during induction of general anesthesia and airway management with endotracheal intubation, 22 (45%) were associated with the use of cricoid pressure, and 19 (39%) were not. This finding of similar percentages of aspiration claims with and without the use of cricoid pressure during induction of general anesthesia suggests that the anesthesia professionals involved in the care of the patients in these claims either did not identify risk factors for aspiration of gastric contents that might have influenced them to use cricoid pressure during induction of general anesthesia or decided to not use cricoid pressure despite the presence of risk factors. If the latter, it is not unexpected. Many previous studies of the use of cricoid pressure and rapid sequence techniques have failed to provide conclusive evidence that they reduce the incidence of perioperative pulmonary aspiration. Neilipovitz and Crosby[17] previously summarized 184 randomized controlled trials regarding the impact of rapid sequence induction during general anesthesia on the incidence of perioperative pulmonary aspiration. They found no compelling evidence that this airway management technique reduced the incidence of aspiration. Birenbaum *et al.*[18] reported on a randomized, double-blind, noninferiority trial from 10 academic medical centers and were unable to find that cricoid pressure *versus* a sham procedure during rapid sequence induction improved the incidence of aspiration. Recently, Zdravkovic *et al.*[19] have questioned the effectiveness of cricoid pressure for reducing the risk of perioperative pulmonary aspiration and noted that its use for this purpose was unsettled and not validated. Our study does not offer any findings to clarify whether or not the use of cricoid pressure during rapid sequence inductions and intubation techniques is effective at preventing aspiration of gastric contents.

Does it help to have assistance from another anesthesia professional when managing the airway of patients with a suspected high risk of pulmonary aspiration? In our aspiration cohort, a single anesthesia professional was caring for patients during 91 of the 115 cases (79%) that documented the presence or absence of additional anesthesia support. Whether or not an additional trained colleague would have reduced the occurrence of aspiration is not known. Notably, only 12 patients in this closed claims series (10%) aspirated when more than one anesthesia professional was present. These data may imply that the presence of a second anesthesia professional might reduce the risk of perioperative pulmonary aspiration. However, our finding may simply reflect that many U.S. practices have only one anesthesia professional available for any given case. It may also be that patients and their legal teams are less likely to pursue medicolegal actions for perioperative pulmonary aspiration when more than one anesthesia professional is involved in the anesthesia episodes of care. Regardless, the impact of the participation of more than one anesthesia professional on the incidence of perioperative pulmonary aspiration remains unclear.

Limitations

Closed claims analysis has many well-described limitations including retrospective analysis, lack of randomization, and selection and hindsight bias that should be considered when interpreting the results.[7] The database lacks denominators and cannot be used to estimate risk. As a consequence, it is not possible to determine any cause–effect relationships. Additionally, there is a significant time lag (*e.g.*, 3 to 7 yr) for malpractice claims to be submitted, adjudicated, and closed. For this reason, our study results may not represent the most current clinical practices.

Data abstraction in the claims for aspiration events relied on narratives by reviewers using primary data sources at liability insurers, which may result in missing information. However, the reliability of assessments by the authors was substantial (κ = 0.61 to 0.80) to excellent (κ = 0.81 to 1.00) on all evaluations except one (κ = 0.576), which was in the higher end of the moderate range (κ = 0.41 to 0.60), lending confidence in these evaluations. Although risk for pulmonary aspiration cannot be determined from these closed claim data, the findings identify patient safety issues and hopefully stimulate future research.

Conclusions

Pulmonary aspiration remains a major perioperative patient safety issue and can be fatal. Patients in this series had many factors previously identified as high-risk for aspiration of gastric contents, especially existing gastrointestinal obstruction. Anesthetic management of patients who experience perioperative pulmonary aspiration was often judged to be substandard. These findings suggest that clinical practice modifications to preoperative assessment and anesthetic management of patients at risk for pulmonary aspiration may lead to improvement of their perioperative outcomes.

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Competing Interests

The authors declare no competing interests.

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References

1. Warner MA, Warner ME, Weber JG: Clinical significance of pulmonary aspiration during the perioperative period. Anesthesiology 1993; 78:56–62
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
3. Cook TM, Woodall N, Frerk C; Fourth National Audit Project: Major complications of airway management in the UK: Results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: Anaesthesia. Br J Anaesth 2011; 106:617–31
4. Bernardini A, Natalini G: Risk of pulmonary aspiration with laryngeal mask airway and tracheal tube: Analysis on 65 712 procedures with positive pressure ventilation. Anaesthesia 2009; 64:1289–94
5. 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; 103:941–7
6. Landreau B, Odin I, Nathan N: [Pulmonary aspiration: Epidemiology and risk factors]. Ann Fr Anesth Reanim 2009; 28:206–10
7. Cheney FW, Posner K, Caplan RA, Ward RJ: Standard of care and anesthesia liability. JAMA 1989; 261:1599–603
8. Sowka M: Malpractice Claims: Final Compilation. Brookfield, Wisconsin, National Association of Insurance Commissioners, 1980
9. Posner KL, Sampson PD, Caplan RA, Ward RJ, Cheney FW: Measuring interrater reliability among multiple raters: An example of methods for nominal data. Stat Med 1990; 9:1103–15
10. U.S. Bureau of Labor Statistics: CPI inflation calculator. Available at: https://www.bls.gov/data/inflation_calculator.htm. Accessed December 12, 2020.
11. Hawkins JL, Chang J, Palmer SK, Gibbs CP, Callaghan WM: Anesthesia-related maternal mortality in the United States: 1979-2002. Obstet Gynecol 2011; 117:69–74
12. Sobhy S, Zamora J, Dharmarajah K, Arroyo-Manzano D, Wilson M, Navaratnarajah R, Coomarasamy A, Khan KS, Thangaratinam S: Anaesthesia-related maternal mortality in low-income and middle-income

countries: A systematic review and meta-analysis. Lancet Glob Health 2016; 4:e320–7
13. D'Angelo R, Smiley RM, Riley ET, Segal S: Serious complications related to obstetric anesthesia: The serious complication repository project of the Society for Obstetric Anesthesia and Perinatology. Anesthesiology 2014; 120:1505–12
14. Perlas A, Arzola C, Van de Putte P: Point-of-care gastric ultrasound and aspiration risk assessment: A narrative review. Can J Anaesth 2018; 65:437–48
15. Perlas A, Chan VW, Lupu CM, Mitsakakis N, Hanbidge A: Ultrasound assessment of gastric content and volume. Anesthesiology 2009; 111:82–9
16. Van de Putte P, Perlas A: Ultrasound assessment of gastric content and volume. Br J Anaesth 2014; 113:12–22
17. Neilipovitz DT, Crosby ET: No evidence for decreased incidence of aspiration after rapid sequence induction. Can J Anaesth 2007; 54:748–64
18. Birenbaum A, Hajage D, Roche S, Ntouba A, Eurin M, Cuvillon P, Rohn A, Compere V, Benhamou D, Biais M, Menut R, Benachi S, Lenfant F, Riou B; IRIS Investigators Group: Effect of cricoid pressure compared with a sham procedure in the rapid sequence induction of anesthesia: The IRIS randomized clinical trial [published correction appears in JAMA Surg 2019; 154:96]. JAMA Surg 2019; 154:9–17
19. Zdravkovic M, Rice MJ, Brull SJ: The clinical use of cricoid pressure: First, do no harm. Anesth Analg 2021; 132:261–7

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Coca: The Sun God's Anesthetic Leaves

Legend had it that *Inti*, Inca god of the sun (*upper left*), had gifted the coca plant (*Erythroxylum coca, right*) to Andean civilization. The Incas chewed coca to combat hunger, fatigue, and sorrow. They offered the holy leaves to the gods and bestowed them upon ennobled warriors. In 1859, sun-drenched coca captivated an Austrian botanist and thus crossed the Atlantic, landing in the hands of a bright and inquisitive chemistry student. Albert Niemann immersed coca leaves in alcohol, treated the extract with milk of lime, sulphuric acid, and sodium carbonate, and then vigorously shook the residue in ether. As the liquid evaporated, glittering crystals emerged. Niemann christened the powder "cocaine" and found that it "benumb[ed] the nerves of the tongue." In 1868, Peruvian surgeon Tomás Moreno y Mayz first suggested that cocaine's desensitizing power might be applied to medicine (*lower left*). In 1884, Sigmund Freud introduced cocaine to ophthalmologist Karl Koller, who famously discovered its topical anesthetic effect, first in the eyes of frogs and rabbits, and then in his very own. However, in spite of the drug's gleaming potential, many physicians who warmed to its light, including Freud and the great surgeon Halsted, were soon scorched by its addictive properties. (Copyright © the American Society of Anesthesiologists' Wood Library-Museum of Anesthesiology, Schaumburg, Illinois.)

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