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Review Article

Pulmonary aspiration during procedural sedation: a comprehensive systematic review

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Abstract

Background. Although pulmonary aspiration complicating operative general anaesthesia has been extensively studied, little is known regarding aspiration during procedural sedation.

Methods. We performed a comprehensive, systematic review to identify and catalogue published instances of aspiration involving procedural sedation in patients of all ages. We sought to report descriptively the circumstances, nature, and outcomes of these events.

Results. Of 1249 records identified by our search, we found 35 articles describing one or more occurrences of pulmonary aspiration during procedural sedation. Of the 292 occurrences during gastrointestinal endoscopy, there were eight deaths. Of the 34 unique occurrences for procedures other than endoscopy, there was a single death in a moribund patient, full recovery in 31, and unknown recovery status in two. We found no occurrences of aspiration in non-fasted patients receiving procedures other than endoscopy.

Conclusions. This first systematic review of pulmonary aspiration during procedural sedation identified few occurrences outside of gastrointestinal endoscopy, with full recovery typical. Although diligent caution remains warranted, our data indicate that aspiration during procedural sedation appears rare, idiosyncratic, and typically benign.

Key words: adverse events; pulmonary aspiration; propofol; sedation

Procedural sedation is widely performed in patients of all ages to facilitate procedures that include dental extraction, endoscopy, bronchoscopy, fracture reduction, abscess drainage, laceration repair, bone marrow aspiration, arthrocentesis, and radiological and cardiac imaging.[1–8] Pulmonary aspiration is a rare but potentially life-threatening complication of sedation, avoidance of which is the goal of preprocedural fasting guidelines. Although aspiration complicating general anaesthesia in theatre has been extensively studied,[9–18] there are few publications regarding aspiration during procedural sedation.[8 19 20] The existing literature comprises occasional case reports and rare mentions in retrospective sedation audits, most of which are related to gastrointestinal endoscopy.

Past and present strategies to avoid aspiration during procedural sedation have by default paralleled those traditionally advocated for theatre, including the specification of nil by mouth (NBM) guidelines.[1–15 19 20] If the circumstances, nature, and outcomes of aspiration during procedural sedation do not parallel conditions associated with aspiration during general anaesthesia, then modification of aspiration strategies (prophylaxis, management, and treatment) may be warranted.[19 20]

We therefore performed a comprehensive, systematic review designed to identify and catalogue all published instances of aspiration during procedural sedation, including gastrointestinal endoscopy but focusing in particular on other settings. Our objective was to detail the circumstances, nature, and outcomes of these events, search for similarities, and then contrast them to the features reported for theatre-related aspiration.

Methods

We performed this review in accordance with the MOOSE guidelines for systematic reviews of observational data.[21] This study was registered with the International Prospective Register of Systematic Reviews (PROSPERO; www.crd.york.ac.uk/PROSPERO/), registration number: CRD42016039039. This analysis was exempt from institutional ethics committee review.

Our medical librarian conducted a search of PubMed, Web of Science, and the Cochrane Library from January 1985 to May 10, 2016, limited to human subjects and the English language. Our specific search strategy in PubMed was as follows: (sedation[tiab] OR "monitored anaesthesia care"[tiab]) AND aspiration[All Fields] AND "humans"[MeSH Terms]. For the other two sources, was the search strategy was as follows: (sedation OR "monitored anaesthesia care") AND aspiration.

We screened titles and abstracts of all articles identified by the search, with full-text review of reports including trials, case series, and case reports of patients receiving procedural sedation. We reviewed the reference lists of identified publications and consulted with topic experts to identify additional reports.

We separately searched the sequential publications of the ASA Closed Claims Database, and searched for applicable closed claims analyses from other locations and specialties.

We searched to identify reports that described one or more specific occurrences of pulmonary aspiration associated with procedural sedation. We defined procedural sedation as 'the use of anxiolytic, sedative, analgesic, or dissociative drugs to attenuate pain, anxiety, and motion to facilitate the performance of a necessary diagnostic or therapeutic procedure, provide an appropriate degree of amnesia or decreased awareness, and ensure patient safety'.[12] We included only procedural sedation performed outside of the operating theatre using natural airways (i.e. no tracheal intubation or laryngeal mask airway support).

Pulmonary aspiration is defined as 'inhalation of oropharyngeal or gastric contents into the larynx and lower respiratory tract',[14] with aspiration pneumonitis defined as an 'event where emesis was noted or food material was found in the oral/pharyngeal cavity—associated with any of the following: new cough, wheeze, increase in respiratory effort, change in chest radiograph indicative of aspiration, or new need for oxygen therapy after recovery from sedation'.[8]

Gastrointestinal endoscopy procedures were evaluated separately, because they are distinct from other procedural sedation in that they involve manipulation and stimulation of the airway/oral cavity. For pulmonary aspiration during gastrointestinal endoscopy, we summarized the information provided regarding aggregate instances described in each report. We pursued greater detail for aspiration during other procedures, extracting—when available—information about the patient (age, co-morbidities, aspiration risk factors, ASA physical status, and fasting), procedure (type, provider, and primary sedative), aspiration event (nature, timing, and presence of pneumonitis), interventions (admission and intubation), and outcomes (death and neurological disability). We also noted when such information was missing or ambiguous and contacted the authors of the reports to request clarification.

Results

Our search and screening process (Fig. 1)[22] identified 35 articles describing one or more occurrences of pulmonary aspiration during procedural sedation.

Our search of the sequential publications of the ASA Closed Claims Database yielded numerous occurrences of aspiration associated with general anaesthesia. The single potentially qualifying instance for the present study was that of a morbidly obese patient who aspirated during 'non-operating room anaesthesia';[23] however, it was not specified whether his or her preplanned management was a natural airway or tracheal intubation. No further details were provided, including procedure, age, outcome, and the anaesthetic or sedative agents used.[23] An analysis from this closed claims database focused specifically on monitored anaesthesia care did not include any instances of aspiration.[24]

An anaesthesia closed claims analysis of the UK National Health Service described no occurrences of aspiration associated with procedural sedation.[25] Major closed claims databases do not exist for dentistry, intensive care medicine, paediatrics, or emergency medicine; however, three limited close claims analyses (one dental and two emergency medicine)[26–28] do not include occurrences of aspiration during procedural sedation.

Our search identified 292 occurrences of aspiration during gastrointestinal endoscopy described in 22 different reports (Fig. 2).[29–44] Most of the identified instances were in adult patients who had substantial underlying illness, with propofol as the principal sedative. The eight deaths resulted from procedures performed for percutaneous endoscopic gastrostomy tube placement (n=4), active gastrointestinal bleeding (n=3), or endoscopic submucosal dissection (n=1).

For procedures other than endoscopy, we identified 34 unique occurrences of aspiration in 17 different reports (Fig. 1).[7 8 34 39 52–62] For additional details, we contacted 16 of these authors with our questions, with 14 providing clarifications. Aspiration during non-endoscopic procedures was more frequently identified in children overall (Table 1), but adults dominated the more serious instances. A variety of indications and providers were represented, with propofol as the most common sedative.

The single death identified for non-endoscopic procedures was in an adult with advanced cancer and substantial underlying illness who underwent colonoscopy, and aspirated despite low sedative doses (midazolam 1 mg plus fentanyl 25 μg). He did not receive aggressive intervention for ensuing respiratory failure. There were no reports of permanent neurological disability. Four other patients required intubation but ultimately recovered; none was ASA physical status I. There were 29 other patients who did not require intubation, including many apparently with minimal symptoms (Table 1).

Discussion

We report the first systematic review of aspiration in procedural sedation and descriptively review this largest available sampling, contrasting these events with what is known about procedural sedation practice and with what is known about aspiration during general anaesthesia. However, a review of this

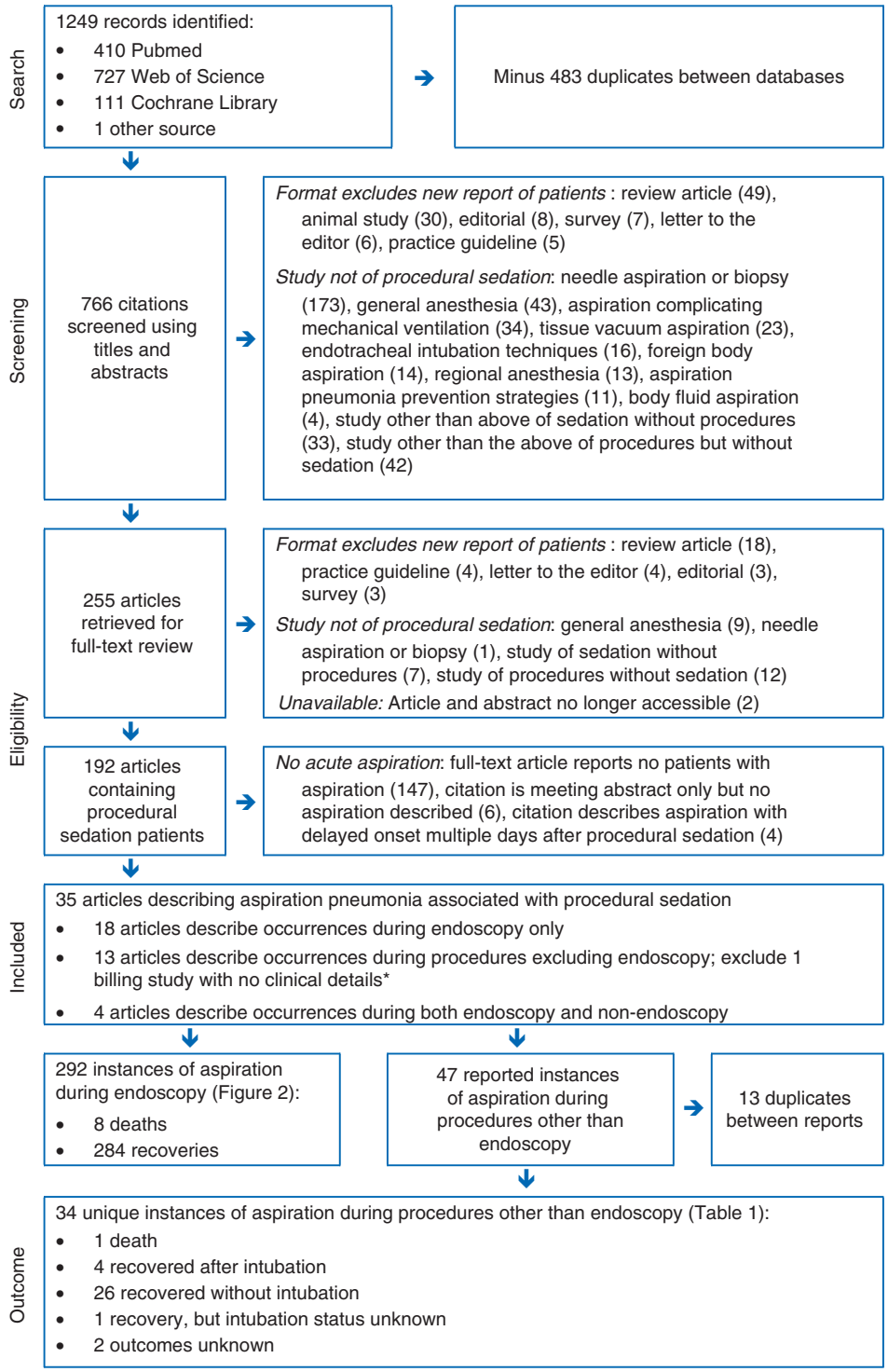

Fig 1 Flow diagram of study selection process. *This study[22] was a search of a Medicare billing database that identified 173 occurrences of 'aspiration pneumonia' billing code within 30 days after colonoscopy; no clinical details are available.

Reports including Deaths Resulting From Aspiration:

- Ayres and colleagues (2014):[29] 13 adults aspirated during either midazolam or general anesthesia-facilitated PEG tube placement; 4 resulting deaths.
- Barbara and colleagues 2015:[30] A 50-yr-old ICU patient aspirated during fentanyl and midazolam facilitated endoscopy for active GI bleeding and suffered cardiac arrest; despite resuscitation he died shortly thereafter of multi-organ failure.
- Kawanishi and colleagues 2016:[31] 24 adults aspirated during diazepam-facilitated endoscopy for active GI bleeding; 3 were intubated and 1 died.
- Park and colleagues 2013:[32] 38 adults aspirated during propofol or midazolam-facilitated endoscopic submucosal dissection; 1 death.
- Sakai and colleagues 2006:[33] an 82-yr-old ASA IV patient with underlying cirrhosis, ascites, and coronary artery disease status post coronary artery bypass grafting underwent endoscopy for GI bleeding after fasting 8 h. An anaesthist provided propofol 75 μg kg^{-1} min^{-1} mcg/kg/min. The patient aspirated and was intubated, developed pneumonia and ARDS and later died. Three other older adults with major underlying medical problems recovered after aspiration pneumonia complicating endoscopy facilitated by anaesthetist-administered propofol infusions. two of these three were intubated.

Reports of aspiration without death:

- Agostoni and colleagues 2011:[34] 13 adults aspirated during propofol-facilitated endoscopy for various indications; no mention of death or outcome other than recovery.
- Beach and colleagues 2016:[8] A 3-yr-old status post visceral transplant aspirated during propofol and ketamine-facilitated endoscopy and required intubation. A 21-month-old with gastric reflux aspirated during propofol-facilitated endoscopy but did not require intubation. both recovered.
- Bosanko and colleagues 2010:[35] 11 adults aspirated during midazolam-facilitated PEG tube placement; no mention of death or outcome other than recovery.
- Byeon and colleagues 2012:[36] 2 adults aspirated during propofol-facilitated double-balloon enteroscopy; both recovered.
- Friedrich and colleagues2014:[37] 29 adults aspirated during propofol-facilitated endoscopy for various indications; none was hospitalized and all recovered.
- Hsieh and colleagues 2011:[38] 5 adults (3 asymptomatic) developed radiographic aspiration during propofol or midazolam-facilitated endoscopy for unknown indications; no mention of death or outcome other than recovery.
- Kamat and colleagues 2014:[39] 3 children aged 21 months, 36 months, and 11 years aspirated during propofol-facilitated endoscopy for unspecified indications; 1 was intubated but all recovered.
- Mao and colleagues 2014:[40] 17 adults aspirated during propofol-facilitated endoscopy for various indications; no mention of death or outcome other than recovery.
- Nayar and colleagues 2010:[41] A 73-yr-old patient aspirated during propofol-facilitated endoscopy for oesophageal cancer staging; she was hospitalized without intubation and recovered.
- Park and colleagues 2013:[42] 32 adults aspirated during propofol or midazolam-facilitated endoscopic submucosal dissection; no deaths.
- Park and colleagues 2014:[43] 9 adults aspirated during propofol and remifentanil-facilitated endoscopic submucosal dissection; no deaths.
- Prout and Metreweli (1972):[44] 16 adults aspirated during diazepam-facilitated endoscopy for unspecified indications; all recovered.
- Tanaka 2007:[45] 2 adults aspirated during pethidine and flunitrazepam-facilitated double-balloon enteroscopy; both recovered.
- Thapa and Mehta (1990):[46] 2 children with aspirated during diazepam-facilitated endoscopy for active variceal bleeding; both recovered.
- Tohda and colleagues 2006:[47] 4 adults aspirated during propofol-facilitated endoscopy for active GI bleeding and were hospitalized; no mention of death or outcome other than recovery.
- Tohda and colleagues 2006:[48] 2 adults aspirated during propofol-facilitated endoscopy for active GI bleeding and were hospitalized; both recovered.
- Walker (2003):[49] 1 adult aspirated during propofol-facilitated endoscopy and required hospitalization.
- Yoo and colleagues 2015:[50] 10 adults aspirated during propofol and remifentanil-facilitated endoscopic submucosal dissection; no mention of death or outcome other than recovery.

Fig 2 Endoscopy-associated aspiration noted in literature search. GI, gastrointestinal; ICU, intensive care unit; PEG, percutaneous endoscopic gastrostomy; ARDS, Acute respiratory distress syndrome.

Table 1 Reported instances of aspiration during procedures other than endoscopy (n=34), sorted by outcome and then age. *In the study by Mallory and colleagues,[57] this patient was inadvertently described as 5 yr old; the author provided the correction. ARDS, acute respiratory distress syndrome; CT, computed tomography; ICU, intensive care unit; MRI, magnetic resonance imaging

Source	Age	Co-morbidities, risk factors	ASA status	Fasting	Procedure	Provider	Principal sedatives	Interventions	Outcome
Aspiration resulted in death									
Kelly and colleagues (2014)[51]	59 yr	Solid organ transplant, advanced oesophageal cancer, cachexia	III	Overnight	Colonoscopy	Gastroenterologist	Midazolam 1 mg and fentanyl 25 μg	Bronchoscopy; death next day	Death
Recovery, but intubation required									
Couloures and colleagues (2011);[52] Beach and colleagues (2016)[8]	10 months	Neurological deficit	II	6 h solids and liquids	MRI scan	Anaesthetist	Propofol	Intubation	Recovery
Agostoni and colleagues (2011)[34]	57 yr	Colon cancer, liver metastases, cachexia	II	6 h solids and liquids; 2 h clear fluids	Colonoscopy	Anaesthetist	Propofol	Intubation	Recovery
Cheung and colleagues (2007)[53]	65 yr	Inebriation	II	6 h solids and liquids	Fracture reduction	Orthopaedist	Propofol	12 h mechanical ventilation	Recovery
Taylor and colleagues (2011)[54]	83 yr	Hiatus hernia	?	24 h solids and liquids	Hip relocation	Emergency physician	Propofol 50 mg and fentanyl 50 μg	Intubation and 2 days in ICU	Recovery
Recovery without intubation									
Babl and colleagues (2015)[55]	16 months	None	I	4 h solids and liquids	Facial laceration	Emergency physician	Nitrous oxide	Unplanned 1 night admission	Recovery
Kamat and colleagues (2015)[39]	24 months	Haematology/oncology	III	8 h solids; 2 h liquids	lumbar puncture (LP) and bone marrow	Intensivist	Propofol	None	Recovery
Srinivasan and colleagues (2012)[56]	25 months	?	I	6 h solids and liquids; 2 h clear fluids	MRI scan	Intensivist	Propofol	Unplanned 1 night admission	Recovery
Couloures and colleagues (2011);[52] Beach and colleagues (2016)[8]	26 months	Dehydration	II	8 h solids and liquids	Central line	Intensivist	Propofol	No intubation	Recovery
Kamat and colleagues (2015)[39]	26 months	Metabolic/genetic	II	8 h solids and liquids	Surgical procedure	Intensivist	Propofol	No intubation	Recovery
Srinivasan and colleagues (2012)[56]	26 months	Optic glioma, hydrocephalus, ventriculoperitoneal (VP) shunt, ex-30 weeks premature	III	6 h solids and liquids; 2 h clear fluids	MRI scan	Intensivist	Propofol	Unplanned 1 night admission	Recovery
Cravero and colleagues (2009);[7] Mallory and colleagues (2011);[57] Couloures and colleagues (2011)[52]	31 months	Seizure disorder	I	6 h solids and liquids; 2 h clear fluids	MRI scan	Emergency physician	Propofol	None	Recovery
Couloures and colleagues (2011);[52] Beach and colleagues (2016)[8]	3 yr	Leukaemia	II	8 h solids and liquids	CT scan	Intensivist	Propofol	No intubation	Recovery
Kamat and colleagues (2015)[39]	3 yr	Haematology/oncology	II	8 h solids and liquids	LP and bone marrow	Intensivist	Propofol	No intubation	Recovery
Beach and colleagues (2016)[8]	5 yr	Brain tumour	II	8 h solids and liquids; 4 h clear fluids	MRI scan	Intensivist	Propofol	No intubation	Recovery

Cravero and colleagues (2006,[58] 2009)[7]	5 yr	Visceral transplant, ex-premature	II	8 h solids and liquids	Colonoscopy	Intensivist	Propofol	Unplanned 1 night admission	Recovery
Kamat and colleagues (2015)[39]	5 yr	Brain tumour	II	8 h solids; 6 h liquids	MRI	Intensivist	Propofol	None	Recovery
Kamat and colleagues (2015);[39] Beach and colleagues (2016)[8]	6 yr	Renal failure	II	8 h solids and liquids; 2 h clear fluids	Renal biopsy	Intensivist	Propofol	No intubation	Recovery
Kamat and colleagues (2015);[39] Beach and colleagues (2016)[8]	6 yr	Leukaemia, upper respiratory infection (URI)	III	8 h solids and liquids; 4 h clear fluids	Bronchoscopy	Intensivist	Propofol	No intubation	Recovery
Cravero and colleagues (2009);[7] Couloures and colleagues (2011)[52]	10 yr	Leukaemia	II	6 h solids and liquids	Lumbar puncture	Anaesthetist	Propofol	Unplanned hospitalization	Recovery
Cravero and colleagues (2009);[7] Mallory and colleagues (2011);[57] Couloures and colleagues (2011)[52]	10 yr*	Neurological work-up	I	6 h solids and liquids; 4 h clear fluids	MRI scan	Emergency physician	Propofol	Unplanned admission	Recovery
Kamat and colleagues (2015);[39] Beach and colleagues (2016)[8]	12 yr	Gastrointestinal disease	II	8 h solids and liquids; 4 h clear fluids	Bronchoscopy	Intensivist	Propofol	No intubation	Recovery
Kamat and colleagues (2015)[39]	14 yr	Haematology/oncology	III	6 h solids; 2 h liquids	LP and chemotherapy	Intensivist	Propofol	None	Recovery
Kamat and colleagues (2015);[39] Beach and colleagues (2016)[8]	15 yr	Lymphoma	III	8 h solids and liquids	Lumbar puncture	Intensivist	Propofol	No intubation	Recovery
Sanborn and colleagues (2005)[59]	Child	?	I or II	Oral contrast; 8 h solids	Imaging	Radiology nurse	Pentobarbital	None required	Recovery
Sanborn and colleagues (2005)[59]	Child	?	I or II	Oral contrast; 8 h solids	Imaging	Radiology nurse	Pentobarbital	None required	Recovery
Agostoni and colleagues (2011)[34]	40 yr	None	I	6 h solids and liquids; 2 h clear fluids	Colonoscopy	Anaesthetist	Propofol	No intubation	Recovery
Agostoni and colleagues (2011)[34]	59 yr	Lung cancer, liver metastases	I	6 h solids and liquids; 2 h clear fluids	Colonoscopy	Anaesthetist	Propofol	No intubation	Recovery
Agostoni and colleagues (2011)[34]	61 yr	Hypertension	II	6 h solids and liquids; 2 h clear fluids	Colonoscopy	Anaesthetist	Propofol	No intubation	Recovery
Thornley and colleagues (2016)[60]	65 yr	Hiatus hernia, gastroesophageal reflux disease (GERD)	?	4 h solids and liquids	Colonoscopy	Anaesthetist	Propofol	No intubation	Recovery
Agostoni and colleagues (2011)[34]	76 yr	Barrett's oesophagus, GERD	II	6 h solids and liquids; 2 h clear fluids	Colonoscopy	Anaesthetist	Propofol	No intubation	Recovery
Recovery, but intubation status unknown									
Vespasiano and colleagues (2007)[61]	Child	?	?	?	?	Intensivist	Propofol	?	Recovery
Outcome unavailable									
Adenipekun and colleagues (1998)[62]	Child	Cancer	?	?	Radiotherapy	Radiotherapist	Diazepam, chlorpromazine, promethazine, paraldehyde	?	?
Adenipekun and colleagues (1998)[62]	Child	Cancer	?	?	Radiotherapy	Radiotherapist	Diazepam, chlorpromazine, promethazine, paraldehyde	?	?

format does not permit us to determine the prevalence of aspiration or to establish risk factors quantitatively.

We identified 292 occurrences during gastrointestinal endoscopy and 34 during other procedures. Gastrointestinal endoscopy clearly entails higher risk, particularly in patients with serious underlying illness, active gastrointestinal bleeding, or both (Fig. 2). For this reason, it is common in most settings to perform such procedures under anaesthesia with airway protection. Four of the eight deaths observed during gastrointestinal endoscopy were in patients undergoing percutaneous endoscopic gastrostomy tube placement. It is unclear whether the apparent greater risk is attributable to the gastric insufflation required to perform the percutaneous endoscopic gastrostomy procedure, the substantial co-morbidities of the patients involved, or both.

The 34 identified non-endoscopic instances represent a spectrum of ages, procedures, underlying illness, and sedation providers (Table 1). We identified fewer reports of aspiration than anticipated, which probably reflects the appropriate skills and experience of the providers most frequently providing such sedation (i.e. anaesthetists or intensivists). Procedural sedation has been widespread for decades, spanning across ages, different sedation providers (physicians and non-physicians), the extremes of health conditions (ASA status), varied NBM conditions, and a wide range of procedures in different contexts. Procedural sedation is administered millions of times annually worldwide. Judging from the published literature, the incidence of aspiration is extremely rare.

In the non-endoscopic subset, it is noteworthy that we found only a single death, and then only in a moribund patient (Table 1). The four other patients who required intubation were also not healthy. We identified no ASA I or II patients who suffered death or permanent disability, and no ASA I patients who required intubation, suggesting a lower risk than is widely presumed among generally healthy patients undergoing procedural sedation.

The largest series identified in our review was that of Beach and colleagues,[8] in which 10 aspirations were noted during 139 142 paediatric procedural sedations (0.0072%). This prevalence is lower than that reported with general anaesthesia, with pooled studies from 1980–1999 noting a prevalence of 0.03%,[20] with later estimates slightly lower: 0.021% (22/102 425),[63] 0.020% (24/118 371),[64] and 0.014% (10/73 007).[33] Aspiration during monitored anaesthesia care has been reported as 0.015% (4/26 434).[33] Accordingly, the best available estimate of the aspiration risk with procedural sedation would appear to be approximately one-third to one-half that of operative anaesthesia. There are theoretical reasons why sedation should entail lesser risk, primarily the decreased frequency of active airway manipulation, the retention of protective airway reflexes as an intended sedation end point, the preferential selection of healthier patients excluding the extremes of age, the avoidance of emetogenic inhalation agents, and the brevity of the sedation required for these simpler procedures.[19 20]

Although the reporting of co-morbidities and aspiration risk factors[19 20] was uneven between reports and often vague, such co-morbidities and risk factors were found in the majority of aspiration occurrences (Table 1). Only two of 34 non-endoscopic patients were described as having no underlying medical conditions. Most patients were at the extremes of age, although this may simply reflect their greater need for medical services.

Aspiration during non-endoscopic procedures was noted in a variety of sedation providers (Table 1). Intensivists were disproportionately represented, probably reflecting the greater underlying illness of their patient population and their greater contribution of observational data to the sedation literature.

The procedures and sedatives used (primarily propofol) reflect a predominant target of deep sedation, supporting the general assumption that this state presents a higher aspiration risk than moderate or mild sedation. Neuroimaging was also a frequently noted indication, and it is possible that elevated intracranial pressure might have been a contributing factor in some occurrences.

Although propofol is likely to be the most common procedural sedation agent used in most settings, ketamine remains a common first or second choice, particularly in children.[58] It is noteworthy that our only occurrence of ketamine-associated aspiration was in subdissociative doses as a secondary adjunct to propofol (Table 1). Ketamine is well known to preserve protective airway reflexes, and our review fails to counter the previous observation that, despite almost 50 yr of continual worldwide use, there are no documented reports—except in medically compromised neonates—of clinically significant aspiration when ketamine is used as the principal sedative.[65] Accordingly, dissociative sedation with ketamine may be an alternative in circumstances of heightened aspiration risk or concern, while recognizing its well-described disadvantages relative to propofol of prolonged recovery, vomiting, and recovery agitation.[65]

Fasting is widely regarded as essential to mitigate aspiration risk and is widely practised for elective sedation. However, large procedural sedation series (including one with 139 142 sedation events)[8] have failed to identify any relationship between fasting and aspiration or other adverse events.[8 66–71]

In our review, every patient with aspiration conformed to NBM guidelines; one exception could be considered in the two children who presented NBM and received oral magnetic resonance imaging contrast agent (Table 1). This administration of oral contrast agent for imaging has been a common practice for decades, and our finding of only two occurrences of aspiration in this setting, both without significant morbidity, supports the previous reports and current practice of accepting minimal to no additional risk from oral contrast materials.[72–74] If foregoing NBM were a clinically important risk factor for aspiration, as widely presumed, adverse events associated with such non-compliance would have been expected to be captured in our sample.

Many regard existing NBM requirements as unnecessarily strict.[75 76] Fasting is uncomfortable, particularly for children, for whom parents are often non-compliant,[77] and can promote dehydration and hypoglycaemia.[78 79] There is also evidence to suggest that prolonged fasting, by creating a state of unease, increases the risk of failed sedations.[80] There are a number of sedation settings in which preprocedural fasting is often overlooked or unenforced without reported problems, such as dentisty,[81] therapeutic abortions,[82] cardiac catheterization,[83] echocardiography,[84] and cataract surgery.[85] Likewise, emergency departments must of necessity sedate patients for urgent or emergent procedures despite the absence of fasting,[19 20 66–69] and one might reasonably expect that such patients would be disproportionately represented in our sample. The only two emergency department patients in our sample had both been fasted before their presentation, although one was inebriated. Although our data support the interpretation that current NBM guidelines have less impact than widely assumed, they do not suggest that fasting should be abandoned or that providers should pay any less attention to screening the preprocedural oral intake of their patients.

Can we predict aspiration? Gastrointestinal endoscopy clearly introduces greater risk, as does deep sedation as the targeted sedation depth. Healthy (i.e. ASA I) patients were uncommon in our non-endoscopic sample, and thus appear to be at particularly low risk.

This review does not suggest greater risk from specific sedation providers or from non-compliance with preprocedural fasting. Underlying illness does appear to be a risk factor (as expected and previously observed);[8 19 20] however, many of the medical conditions observed (Table 1) are common in patients requiring procedural sedation. Accordingly, aspiration appears largely idiosyncratic and unpredictable. There are likely to be other contributory factors that cannot be quantified in a review of our format, including the frequency and contribution of intraprocedural airway manipulations, such as forceful bag-and-mask ventilation for upper airway obstruction.

The principal limitation of our review is that it identified only the reported instances of aspiration, and not the sedation denominator such that aspiration prevalence could be estimated. Additionally, we could only access occurrences of aspiration reported in the medical literature, and thus cannot exclude the possibility of death or permanent disability complicating aspiration that went unreported in peer-reviewed journals. However, it is noteworthy that a compilation of anecdotal 'sedation disasters' failed to identify a single instance of associated aspiration during a 27 yr study period.[86 87]

A further limitation is that our report cannot provide insights into the experience and judgment of the providers. Although many of our patients were low risk, others were clearly not (e.g. active gastrointestinal bleeding, higher ASA physical status), and it is not clear why sedation was chosen in these latter circumstances rather than anaesthesia with airway protection. We believe that the aspiration-related morbidity and mortality in our present report can further inform such decision-making, and strongly supports the advisability of referring high-risk patients whenever possible for anaesthetic management.

The NBM guidelines differ between specialties and settings, and therefore we are unable to specify the fasting intervals for each report. Finally, we were limited by the details of these patients that either were originally reported or could be later identified by their authors.

Conclusion

This systematic review identified rare occurrences of pulmonary aspiration complicating non-endoscopic procedural sedation, with full recovery being typical. There were no occurrences of aspiration in patients non-compliant with NBM criteria. Although diligent caution remains warranted, our data indicate that aspiration during procedural sedation appears rare, idiosyncratic, and typically benign.

Authors' contributions

Formulation of study design: S.M.G., K.P.M., B.S.K.
Data acquisition and analysis, drafting of manuscript: S.M.G.
Critical revision of manuscript for important intellectual content: K.P.M., B.S.K.
Approval of the final version of the manuscript: S.M.G., K.P.M., B.S.K.

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Declaration of interest

None declared.

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