Aspiration under anaesthesia: risk assessment and decision-making

Revalidation FOR ANAESTHETISTS
RCA Revalidation matrix
Matrix reference 1C01, 1I03, 2A03

Michael Robinson MB ChB FRCA
Andrew Davidson MA MBBS FRCA FFICM

Key points

- Judgement of aspiration risk is a key to airway management in anaesthesia.
- Aspiration accounted for more deaths than failure to intubate or ventilate in the Royal College of Anaesthetists 4th National Audit Project (NAP4) data.
- Anaesthetists must identify and act upon indications for rapid sequence induction.
- Aspiration events in NAP4 were highest in emergency anaesthesia delivered by trainees.
- If risk of aspiration is present, extubation awake in the lateral position is advised.

Michael Robinson MB ChB FRCA
Speciality Registrar Anaesthesia and Clinical Leadership Fellow
Doncaster and Bassetlaw Hospitals Foundation Trust
Doncaster Royal Infirmary
Armthorpe Road
Doncaster
South Yorkshire
DN2 5LT
UK

Andrew Davidson MA MBBS FRCA FFICM
Consultant Anaesthetist
Sheffield Teaching Hospitals
Royal Hallamshire Hospital
Glossop Road
Sheffield
South Yorkshire
S10 2JF
UK
Tel: +44 (0) 114 271 1900
Fax: +44 (0) 114 2762077
Email: andrew.davidson@sth.nhs.uk
(for correspondence)

Pulmonary aspiration complicates between 1 in 900 to 1 in 10 000 general anaesthetics,[1] dependent on risk factors. All novice anaesthetists in the UK are taught to consider the risk of aspiration and to modify their anaesthetic technique accordingly. The prevention of aspiration remains a cornerstone of anaesthetic practice.

The recent Royal College of Anaesthetists 4th National Audit Project[2] (NAP4) collected data on the incidence and causes of major airway complications in the UK. Over 50% of airway-related deaths in anaesthesia were as a consequence of aspiration, outweighing the much feared can't intubate can't ventilate (CICV) scenario. In addition, 23% of all cases reported to NAP4 involved aspiration as either the primary or secondary event. Cases not resulting in death commonly resulted in significant morbidity and prolonged stay on intensive care.

Despite the awareness among anaesthetists of the need to minimize the risks of aspiration and advances in anaesthetic practices, NAP4 provided evidence that aspiration often occurred as a consequence of incomplete assessment of aspiration risk or a failure to modify anaesthetic technique. This review aims to highlight the key findings from NAP4 with regard to aspiration and evaluates the literature on aspiration risk assessment and decision-making.

Definition

Pulmonary aspiration is defined by the inhalation of oro-pharyngeal or gastric contents into the larynx and the respiratory tract. Mendelson[3] described the potential consequences of abolished airway reflexes under anaesthesia and the subsequent aspiration of gastric contents, which became synonymous with Mendelson's syndrome.

Aspiration of solid matter can cause hypoxia by physical obstruction, whereas aspiration of acidic gastric fluid can cause a pneumonitis with the syndrome of progressive dyspnoea, hypoxia, bronchial wheeze and patchy collapse, consolidation on chest X-ray or all. The risk of mortality and serious morbidity increases with bronchial exposure to greater volumes and acidity of aspirated material.

Incidence of aspiration and anaesthesia-associated fatal aspiration

The incidence of anaesthesia-associated fatal aspiration in NAP4[2] was ~1 in 350 000, which is lower than the historical estimates of between 1 in 45 000 and 1 in 240 000. Aspiration, however, remains the most significant cause of airway-related mortality. It was responsible for 8 of the 16 (50%) anaesthetic deaths and 23 of the 133 (17%) reported primary anaesthesia events, defined as airway complications leading to death, brain damage, unanticipated ICU admission, or the need for an emergency surgical airway.

The incidence of aspiration under anaesthesia remains significantly greater with higher ASA status and emergency surgery.[1]

Normal physiological mechanisms to prevent aspiration of gastric contents[4]

The gastro-oesophageal junction, upper oesophageal sphincter, and protective laryngeal reflexes provide the normal physiological mechanisms to reduce the risk of aspiration, and are all attenuated by drugs used to induce and maintain general anaesthesia.

Gastro-oesophageal junction

The acute angle formed anatomically between the distal oesophagus and stomach at the gastro-oesophageal junction assists the lower oesophageal sphincter (LOS), formed from a section of the distal oesophagus, in protecting the oesophagus from gastric acid reflux. Reinforced by the crura of the diaphragm, LOS resting pressure

doi:10.1093/bjaceaccp/mkt053 Advance Access publication 21 November, 2013

exceeds gastric pressure creating a physiological barrier to gastro-oesophageal reflux, known as barrier pressure.

Reflux of gastric contents into the oesophagus occurs in both healthy individuals and those with pathological gastro-oesophageal reflux disease (GORD) when the LOS transiently relaxes in the absence of swallowing. Although there is no significant difference in the frequency of transient LOS relaxation between healthy people and those with pathological GORD, transient LOS relaxation is more likely to be associated with acid reflux in patients with GORD.[5]

In hiatus hernia, the proximal stomach enters the thorax, thereby diminishing the acute angle between the oesophagus and the stomach, and preventing the reinforcement of the LOS by the diaphragmatic crura. The resulting reduction in maximal LOS pressure reduces barrier pressure and increases the likelihood of reflux.

During anaesthesia reflux may occur because barrier pressure is reduced by pharmacodynamic relaxation of the LOS caused by anticholinergics, thiopental, opioids, and inhalation anaesthetic agents.

Upper oesophageal sphincter

Cricopharyngeus, the inferior constrictor muscle of the pharynx, acts in combination with thyrophayngeus and the cervical oesophagus to form the functional upper oesophageal sphincter (UOS). Cricopharyngeus originates from the cricoid cartilage, to loop around the pharynx before inserting into the contralateral side of the cricoid cartilage. The UOS acts to prevent the reflux of oesophageal contents into the pharynx in conscious individuals.

UOS tone is reduced in patients with reduced consciousness and attenuated by most drugs used for the induction and maintenance of anaesthesia with the notable exception of ketamine. Both depolarizing and non-depolarizing neuromuscular blocking agents reduce UOS tone, and some evidence suggests that residual neuromuscular block significantly reduces UOS tone for a significant time after emergence, increasing the risks of aspiration during the recovery phase.

Protective airway reflexes[4]

Protective upper airway reflexes include coughing, expiration and laryngospasm. These protective reflexes are variably affected by reduced levels of consciousness and may be reduced at any stage of the perioperative period, including after emergence. Elderly patients are particularly prone to higher risks of aspiration under anaesthesia because they, in general, have less active airway reflexes.[4]

Risk factors for the aspiration of gastric contents

The vast majority of anaesthetic techniques attenuate the protective physiological mechanisms that prevent regurgitation and aspiration. Inadequate depth of anaesthesia or unexpected responses to surgical stimulation may evoke gastrointestinal motor responses, such as gagging or recurrent swallowing, increasing gastric pressure over and above LOS pressure facilitating reflux.[6] In the setting of aspiration, regurgitation occurs three times more commonly than active vomiting.[7]

An unprotected airway, excessively light depths of anaesthesia, and one or more predisposing risk factors for aspiration combine to significantly increase the risks of aspiration.

NAP4[2] highlighted that poor judgement was the likely root cause in many cases of aspiration. Poor assessment of patient and operative risks, and failure to use airway devices or techniques offering greater protection against aspiration were common themes.

The predisposing risk factors for aspiration can be classified by patient factors, operative factors, anaesthetic factors, or device factors (shown in Box 1). There is a variation in the effect of individual risk factors on overall aspiration risk, but gastrointestinal pathology and pregnancy both markedly increase aspiration risk. Pathology of the gastrointestinal tract delays gastric emptying, ensuring a 'full stomach', and impairs the function of the LOS. These effects are compounded in emergency surgery and if the lithotomy position is used.

Box 1 Risk factors for aspiration (adapted from Asai[6] with permission from the British Journal of Anaesthesia)

Patient factors

(a) Full stomach
- Emergency surgery
- Inadequate fasting time
- Gastrointestinal obstruction

(b) Delayed gastric emptying
- Systemic diseases, including diabetes mellitus and chronic kidney disease
- Recent trauma
- Opioids
- Raised intra-cranial pressure
- Previous gastrointestinal surgery
- Pregnancy (including active labour)

(c) Incompetent lower oesophageal sphincter
- Hiatus hernia
- Recurrent regurgitation
- Dyspepsia
- Previous upper gastrointestinal surgery
- Pregnancy

(d) Oesophageal diseases
- Previous gastrointestinal surgery
- Morbid obesity

Surgical factors
- Upper gastrointestinal surgery
- Lithotomy or head down position
- Laparoscopy
- Choleocystectomy

Anaesthetic factors
- Light anaesthesia
- Supra-glottic airways
- Positive pressure ventilation
- Length of surgery > 2 h
- Difficult airway

Device factors
- First-generation supra-glottic airway devices

In pregnancy, the gravid uterus displaces the stomach, so altering the angle formed between the oesophagus and stomach. This effect is exacerbated by maternal obesity, multiple pregnancy, and polyhydramnious. Higher concentrations of progesterone reduce barrier pressure further by relaxing the LOS, whilst decreased concentrations of the peptide hormone motilin delays gastric emptying.

The aspiration of blood

Aspirated blood is most commonly associated with intra-oral surgery or tonsillectomy. Aspirated blood may clot, causing total airway obstruction and death if not recognized promptly.

NAP4[2] documented two deaths caused by the aspiration of blood after extubation, one after dental surgery and the other in a child after routine tonsillectomy. Ventilation after re-intubation was only possible after sizeable blood clots were aspirated from the trachea. Inadequate use of capnography contributed to deaths in both cases. In one of the cases, there was no evidence of its use after re-intubation, and in the other a flat capnograph trace, indicating failure of ventilation, was misinterpreted.

Risk reduction strategies for the aspiration gastric contents

The multiple strategies available to anaesthetists to reduce the risk of aspiration are summarized in Table 1.

After a review of 5000 closed claims, an Australian study recommended more didactic guidelines (Table 2), which if used would have potentially reduced the incidence of aspiration by up to 60%.[7]

The guidelines recommended anaesthetists to extubate all patients on their sides. However, contrary to this advice, a survey of anaesthetic practice noted the emerging trend to manage extubation in the head-up or sitting position.[8] The survey revealed that 90 out of 593 consultant anaesthetists (15%) manage some emergency patients in the supine position for extubation. Worryingly, evidence suggests that even when the risk of regurgitation is high enough to indicate rapid sequence induction, the same logic is not applied to extubation, when the risk of regurgitation is unlikely to have diminished. The tendency to view aspiration risk as only relevant at induction contradicts evidence that aspiration also occurs during maintenance (13 of 23 cases in NAP4)[2] and during emergence (1 in 23 cases in NAP4).[2] Other studies have shown that up to 20% of aspiration occurs after extubation.[7]

Table 1 A summary of the available strategies for reducing aspiration risk

Reducing gastric volume	Preoperative fasting Nasogastric aspiration Prokinetic premedication
Avoidance of general anaesthetic	Regional anaesthesia
Reducing pH of gastric contents	Antacids H_2 histamine antagonists Proton pump inhibitors
Airway protection	Tracheal intubation Second-generation supra-glottic airway devices
Prevent regurgitation	Cricoid pressure Rapid sequence induction
Extubation	Awake after return of airway reflexes Position (lateral, head down or upright)

Table 2 Guidelines to reduce the risk of aspiration[7]

1. Experienced anaesthesia assistance available to all times
2. Intubate all emergency cases
3. Apply appropriate cricoid pressure with all inductions using neuromuscular blocking agents
4. Intubate/seriously consider intubation in the following:
   Delayed gastric emptying (pregnancy, opioids, diabetes mellitus, renal failure)
   Increased intra-abdominal pressure (obesity, ascites, masses)
5. Extubate high-risk cases awake and on their side. Extubate all others on their side

The guidelines (Table 1) are contentious given the recommendation to use cricoid pressure whenever neuromuscular blocking agents are used. Cricoid pressure can increase the frequency of difficult intubation, especially if excessive force is used, and the evidence base does not robustly support its effectiveness in reducing regurgitation. So, whilst the universal use of cricoid pressure may reduce regurgitation, the recommendation needs to be balanced by the likelihood that it would increase problems with intubation.

The management of aspiration

If aspiration occurs, management is directed to supportive treatment and organ support. Anaesthetists should have a low index of suspicion and recognize aspiration should it occur. The trachea should be suctioned once the airway is secure, ideally before positive pressure ventilation to prevent the distal displacement of aspirated material.

Aspiration will more commonly affect the right lung because the right main bronchus is more vertical than the left main bronchus. Early chest X-ray will show consolidation in up to 75% of cases and early bronchoscopy may help prevent distal atelectasis if particulate matter has been aspirated.

Aspiration may lead to a variety of clinical conditions, including chemical pneumonitis, bacterial pneumonia, or adult respiratory distress syndrome. Mechanical ventilation may be required for prolonged periods.

The main controversies surrounding treatment decisions involve the decision to use antibiotics and steroids. Antibiotics should only be used if pneumonia develops, as early antibiotics may lead to the

selection of virulent bacteria including pseudomonas. There is no evidence that using steroids either reduces mortality or improves outcome.[9]

Microaspiration and ventilator-associated pneumonia

Ventilator-associated pneumonia (VAP) is predominantly caused by microaspiration and strategies should be used to reduce the risk of VAP. Tracheal tubes, which allow subglottic secretion drainage, help reduce the incidence of VAP and subsequently the duration of mechanical ventilation.[10] Ensuring that patients, especially those expected to require mechanical ventilation for >72 h, are intubated with tracheal tubes with subglottic secretion drainage will mitigate the effects to microaspiration and reduce the associated VAP.[9]

Why do patients still die from aspiration under anaesthesia? Trainees, training, or culture?[2]

The recent NAP4[2] study shows ongoing evidence of aspiration occurring in patients with recognized risk factors. The authors described 'clear examples of aspiration occurring at induction when classical indications for rapid sequence induction were present and not used'. There was a significant number of aspirations during maintenance of anaesthesia when first-generation laryngeal masks were used and there was an overall impression of a 'failure to identify risk and a failure to use available precautions to reduce the risks'.

NAP4[2] found that an excess of aspiration cases involved emergency surgery and trainee anaesthetists. Fifteen of the 29 cases with primary or secondary aspiration were anaesthetized by trainees. Perhaps it is not surprising that trainees and emergency surgery supplied an excess of cases. Emergency surgery significantly increases the risk of aspiration and arguably trainees may anaesthetize a higher proportion of emergency cases than consultants.

Worryingly the NAP4[2] questionnaire found the failure of risk assessment to be a persistent theme. Of the 23 cases of primary anaesthesia-related aspiration, only 10 (43.4%) were thought at the time of surgery to have had any risk factors for aspiration. However, retrospectively 9 of the 11 patients initially described as having no risk factors had at least one risk factor for aspiration. Indeed of all the patients who aspirated, 27 of 29 patients had identifiable risk factors (93.1%).

Developing strategies to reduce the harm associated with aspiration require us to consider the reasons why risk assessment of aspiration fails to influence the anaesthetic technique. Even emergency patients with the highest risk have a relatively low risk of aspiration in absolute terms. The first few times an anaesthetist chooses not to use recommended strategies to mitigate the risk of aspiration may result in no harm, thus confirming the belief that aspiration risk is overestimated. The high proportion of cases involving trainees brings into question the supervision, departmental support, training, and culture within hospitals.

As with other risk–benefit analyses, aspiration risk can be thought of as a continuous spectrum. There are patients with low risk and some with high risk, but there is also likely to be many cases with an intermediate risk. Such a spectrum will reduce the effectiveness of a standardized risk assessment tool to inform decision-making.

As is often the case during surgery, any of the incidents in NAP4 involve non-technical skills and human factors. Box 2 highlights four of the cases, which demonstrates some of the issues including poor decision-making, poor handovers, poor supervision and support for trainees, and a lack of communication. The NAP4[2] authors also identified a lack of planning and a lack of situational awareness as contributory individual factors to many of the serious incidents.

Box 2 Specific examples of human factors documented in NAP4[2]

1. A trainee anaesthetist planned routine intubation for an elderly obese patient requiring repair of a strangulated hernia. The patient aspirated at induction and was admitted to ICU. The anaesthetist was not made aware of, and failed to discover, the presence of intestinal obstruction or that the patient had been actively vomiting on the ward.
2. An anaesthetist assessed an elderly patient, who had presented with a severe abscess. The initial anaesthetist decided RSI in theatre was indicated, but before anaesthesia there was a change of anaesthetist, who judged that RSI was not indicated. The patient aspirated during transfer from the anaesthetic room to theatre, and required ICU admission.
3. An elderly patient was anaesthetized for fractured neck of femur surgery. The patient had recently had pseudo-obstruction, but a laryngeal mask was used to manage the airway. The patient regurgitated and aspirated during maintenance of anaesthesia. The patient was intubated and required ICU admission after surgery.
4. A very junior anaesthetist anaesthetized an elderly ASA3 patient with heart failure, as an emergency out-of-hours. The patient aspirated after induction for an RSI. It was unclear whether cricoid force was applied. The patient was extubated but deteriorated during the next day and required ICU admission.

Team and organizational factors included a lack of team training and a poor adherence to existing guidelines. It is interesting to speculate why healthcare professionals might poorly adhere to existing guidelines. One argument suggests that coping well with uncertainty is a necessary attribute for healthcare professionals. Individuals who cope well with uncertainty are less likely to follow guidelines and protocols.

Over the past two decades, there has been an increasing awareness of the role of simulation in understanding and mitigating issues related to human factors. NAP4 provides additional evidence, if any

were needed, that emphasis on future training should concentrate on effective team working, communication and non-technical skills.

Box 3 shows a summary of the specific recommendations from NAP4 regarding aspiration. Most, if not all, anaesthetists would consider the guidance to be common sense. Perhaps the most significant way to reduce unnecessary harm from aspiration is changing the culture of anaesthetic training and practice to ensure that the valuable learning from studies, such as NAP4,[2] is more than documentary evidence of harm, but is put into action for the benefits of patients.

Box 3 Summary of recommendations from NAP4 on aspiration[2]

1. All patients must be assessed for aspiration risk before surgery, especially urgent and emergency cases. In cases of doubt, the higher risk should be assumed.
2. Airway management strategies should be consistent with identified risk.
3. The equipment and skills to detect and manage regurgitation and aspiration should be available at all times.
4. Rapid sequence induction remains the standard technique for airway protection.
5. Those applying cricoid pressure should be trained in its application and practice applying cricoid pressure regularly.
6. In cases where tracheal intubation is not indicated, but when a small increase in aspiration exists, Second generation supraglottic airways should be considered.
7. Strategies should be used to reduce aspiration at emergence if the patient is at risk of aspiration.
8. Anaesthetists should be aware of the prevention, detection and management of blood clot aspiration.
9. Active measure should be taken when a flat capnography trace occurs when blood has been near the airway.

Conclusion

The assessment and recognition of risk factors for pulmonary aspiration is a basic fundamental aspect of anaesthetic training and practice. Learning from research and case studies should reduce these risks by reinforcing the need for active modification of airway management. Emergency anaesthesia on its own is a simple important risk factor for aspiration. Extubation awake, in the lateral position, is recommended if aspiration risk is present. Second-generation supra-glottic devices may be superior to first-generation devices, but rapid sequence tracheal intubation remains the most supported technique.

Declaration of interest

None declared.

References

1. Warner MA, Warner ME, Weber JG. Clinical significance of pulmonary aspiration during the peri-operative period. *Anesthesiology* 1993; **78**: 56–62
2. Cook T, Frerk C. *4th National Audit Project (NAP 4): Major Complications of Airway Management in the United Kingdom Report and Findings—Chapter 19. Aspiration of gastric contents and of blood.* March 2011, The Royal College of Anaesthetists and The Difficult Airway Society
3. Mendelson CL. The aspiration of stomach contents into the lungs during obstetric anesthesia. *Am J Obstet Gynecol* 1946; **52**: 191–205
4. Ng A, Smith G. Gastroesophageal reflux and aspiration of gastric contents in anaesthetic practice. *Anesth Analg* 2001; **93**: 494–513
5. Hershcovici T, Mashimo H, Fass R. The lower esophageal sphincter. *Neurogastroenterol Motil.* 2011; **23**: 819–30
6. Asai T. Who is at risk of pulmonary aspiration? *Br J Anaesth* 2004; **93**: 497–500
7. 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
8. Rassam S, Sandbythomas M, Vaughan RS, Hall JE. Airway management before, during and after extubation: a survey of practice in the United Kingdom and Ireland. *Anaesthesia* 2005; **60**: 995–1001
9. Muscedere J, Dodek P, Keenan S, Fowler R, Cook D, Heyland D. Comprehensive evidence-based clinical practice guidelines for ventilator-associated pneumonia: prevention. *J Crit Care* 2008; **23**: 126–37
10. Muscedere J, Rewa O, McKechnie K, Jiang X, Laporta D, Heyland DK. Subglottic secretion drainage for the prevention of ventilator-associated pneumonia: a systematic review and meta-analysis. *Crit Care Med* 2011; **39**: 1985–91
11. Brimacombe JR, Berry A. The incidence of aspiration associated with the laryngeal mask airway: a meta-analysis of the published literature. *J Clin Anesth* 1995; **7**: 297–305
12. Beck-Scimmer B, Bonvini JM. Bronchoaspiration: incidence, consequences and management. *Eur J Anaesthesiol* 2011; **28**: 78–84

Please see multiple choice questions 21–24.