Pulmonary aspiration of oropharyngeal or gastrointestinal content into the larynx and lower respiratory tract to the lungs is an important cause of morbidity and mortality in both anaesthesia and critical care settings. Aspiration was first recognised as a cause of an anaesthetic-related death in 1848 by James Simpson. Mendelson reported two syndromes involving the aspiration of gastric contents and described the relationship between aspiration of solid and liquid matter, and pulmonary sequelae in obstetric patients.

The North American Summit, on aspiration in critically ill patients has defined aspiration as inhalation of material into the airway below the level of the true vocal cords. The aspiration of oropharyngeal secretion may go unnoticed as in case of patients with impaired cough reflex or depressed consciousness (silent aspiration or asymptomatic aspiration) or may result in coughing, choking, shortness of breath and/or respiratory distress (symptomatic aspiration). Other terms commonly described in this context are aspiration pneumonitis and aspiration pneumonia. The term “aspiration pneumonitis” refers to a non-infectious acute inflammatory reaction to aspirated material and “aspiration pneumonia” is a parenchymal inflammatory reaction to bacterial load in the aspirated material. Both aspiration pneumonitis and pneumonia are characterized by an infiltrate on chest radiograph.
Incidence, morbidity and mortality

The reported incidence of pulmonary aspiration is three for 10,000 anaesthetic procedures and the incidence increases by four-to 12-fold in “at risk” populations like obstetrics patients and during emergency procedures.\(^4\)

A study from India in critically ill patients\(^5\) found that, incidence of gastrointestinal aspiration was high and had a significant correlation with lower respiratory tract infection (LRTI).\(^3\)

Two studies from USA,\(^6,7\) reported an incidence of pulmonary aspiration of 1 in 3216 anaesthetic procedures with resulting morbidity and mortality of 1 in 16576 and 1 in 71829 respectively. A similar incidence of aspiration was observed both in adults (3.1/10,000) as well as children (3.8/10,000).\(^6,7\)

Pathophysiology

The pathophysiologic mechanism resulting in pulmonary aspiration includes a defective barrier involving the lower oesophageal sphincter (LOS), the upper oesophageal sphincter (UOS), and the laryngeal reflexes.

**Lower oesophageal sphincter**

The LOS acts as a valve between the stomach and the lower oesophagus, a point, where oesophagus makes an acute angle with the gastric fundus and contraction of the right crus of the diaphragm forms a sling around the abdominal oesophagus.\(^8\) Barrier pressure is the difference between LOS pressure (normally 20-30 mm Hg) and intragastric pressure (normally 5-10 mm Hg) and both are influenced by a number of factors. A reduction in barrier pressure (a low LOS or high intragastric pressure) is the major physiological derangement in patients with gastro-oesophageal reflux during anaesthesia and in disease states. LOS pressure is reduced by peristalsis, vomiting, during pregnancy (a progesterone effect) as well as pathological conditions such as achalasia and various drugs. Antiemetics, cholinergic drugs, succinylcholine, and antacids increase LOS pressure, while anticholinergic, thiopental, opioids, and inhalational anaesthetics reduce LOS pressure. Drugs like atracurium, vecuronium, ranitidine, and cimetidine have no effect on LOS pressure.\(^9\)

Intragastric pressure is increased if the gastric volume exceeds 1000 mL, and with raised intra-abdominal pressure such as that occurring with pneumoperitoneum and lithotomy position.

**Upper oesophageal sphincter**

The cricopharyngeus muscle acts as the functional UOS. It is one of the two inferior constrictor muscles of the pharynx. It extends around the pharynx from one side of the cricoid arch to the other and is continuous with the circular muscular coat of the esophagus.\(^10\) In conscious healthy patients, the UOS helps to prevent aspiration by sealing off the upper oesophagus from the hypopharynx. Most anaesthetic techniques, possibly with the exception of ketamine, are likely to reduce UOS tone and increase the likelihood of regurgitation of material from oesophagus into the hypopharynx.\(^11\)-\(^13\) In addition, a numerical end-point like “train of four” of 0.7 on a peripheral neuromuscular block monitor in patients who have received neuromuscular blocking drugs, may not protect against aspiration, because of reduction in UOS tone and impaired swallowing.\(^14\)

**Laryngeal reflexes**

Unconscious patients are at risk of aspiration because of impaired airway reflexes, but the relationship between a reduced conscious level and these reflexes is not straightforward and within a Glasgow coma score range of 3-8, normal cough reflex may or may not exist.\(^15\)

The four laryngeal airway reflexes found in upper airways responsible for protecting against aspiration are,\(^16\) (i). apnoea with laryngospasm: during this reflex, there is closure of both the
false and true cords. If laryngospasm is prolonged, the false cords relax while the true cords remain constricted; (ii) coughing reflex is a forceful expiratory effort preceded by a brief period of inspiration. The false cords open wider during expiration than inspiration. The larynx, trachea, bronchus, and, Oesophagus are the sensory site for the initiation of coughing; (iii) expiration reflex is a forceful expiratory effort without a preceding inspiration. Sudden opening of the glottis follows closure of the false cords; and (iv) spasmodic panting reflex involves shallow breathing at a frequency of 60 breaths per minute for less than 10 sec. The glottis opens and closes rapidly.

The larynx and trachea are more sensitive than the bronchus in eliciting these protective airway reflexes. The oesophagus is also thought to be a sensory site for the initiation of coughing. In two studies, desflurane was found to be superior to sevoflurane in terms of rapid return of protective airway reflexes at emergence in patients with higher body mass indexes who are at greater risk of aspiration during early recovery from anaesthesia.

Other studies reported that, patients may have reduced airway reflex sensitivity, not only during the intraoperative and postoperative period but also in the preoperative period if premedicated with diazepam or are elderly (aged above 65 years).

Factors predisposing to pulmonary aspiration

The factors that predispose a patient to pulmonary aspiration are listed in Table 1. The factors responsible for pulmonary aspiration include: (i). incompetent tone (LOS/UOS)/increased tendency to regurgitate; (ii). increased gastric pressure; and (iii). impaired airway reflexes. Any of these conditions, if associated with altered consciousness, periodontal disease tilt the balance towards development of a bacterial pneumonia instead of simple chemical pneumonitis.

Detection of gastric aspiration

If pulmonary aspiration is not witnessed and, or tracheal suction does not reveal gastric contents or enteral feeds, there are no specific diagnostic tests to confirm pulmonary aspiration of gastric contents.
Prevention of aspiration in critical care

Critically ill patients have an increased risk for aspirating oropharyngeal secretions and regurgitated gastric contents. In particular patients who are enteral fed with a gastric tube; aspiration of gastric contents is of greater concern. Small volume asymptomatic aspirations are very common whereas a witnessed large-volume aspirations occur infrequently.

Many study suggested use of a 30° to 45° head-of-bed elevation, unless contraindicated. In a multivariate analysis considering selected risk factors (chronic lung failure, use of H2 blockers, and supine head position) into a logistic regression model, supine head position was found to be an independent risk factor for ventilator associated pneumonia.

The following measures are helpful in preventing pulmonary aspiration from occurring in critical care scenarios.

Endotracheal cuff pressures should be maintained at an appropriate level (21-29 cm of H2O) and it should be ensured that secretions are cleared from above the cuff before it is deflated. Sedatives should be used as sparingly as feasible because their interference with gastric emptying and normal cough clearance mechanism. For patients receiving enteral gastric tube feedings, assessment for both gastrointestinal intolerance to the feedings and placement of the feeding tube (to ensure the tube has remained in the desired location) must be carried out at 4-hour intervals. The current level of evidence does not conclusively recommend regarding the best type of formula delivery method (continuous

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patient factors</th>
<th>Surgical factors</th>
<th>Anaesthesia ICU factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased tendency to regurgitate</td>
<td>Oesophageal stricture / carcinoma, Zenker’s diverticulum, achalasia, diabetic autonomic neuropathy, hiatus hernia, gastro-oesophageal reflux, pregnancy, morbid obesity, neuromuscular disease, male, elderly</td>
<td>Pneumoperitoneum, lithotomy, emergency abdominal pathology</td>
<td>Opioids, misplaced nasogastric tube, improper Sellick’s manoeuver, inadequate anaesthesia</td>
</tr>
<tr>
<td>Increased gastric content</td>
<td>Delayed gastric emptying, gastric hypersecretion, intestinal obstruction non-fasting state, drugs</td>
<td></td>
<td>Non-adherence to fasting guidelines, over feeding, air/gas insufflation, difficult tracheal intubation</td>
</tr>
<tr>
<td>Impaired airway reflexes</td>
<td>Head injury, bulbar palsy, neuromuscular disorders (multiple sclerosis, Parkinson’s disease, Guillain-Barre syndrome), muscular dystrophy (cerebral palsy, cranial neuropathies, trauma, burns)</td>
<td></td>
<td>Residual neuromuscular paralysis</td>
</tr>
</tbody>
</table>

ICU = intensive care unit
or intermittent). However, use of continuous feeding over bolus feeding was documented in one study based on the observation that pulmonary aspiration was a more common finding in those with intermittent feedings (3 of 17) than in those who received continuous feedings (1 of 17). Swallowing assessment must be carried out before oral feedings are started for recently extubated patients who have experienced prolonged intubation as such patients may experience a variable degree of impaired laryngeal reflexes and swallowing reflex to variable length of time.

**Prevention of aspiration in anaesthesia practice**

The following measures are helpful in preventing pulmonary aspiration in anaesthesia practice.

Fasting guidelines must strictly adhered to. Current guidelines recommend fasting time for clear fluids is 2 hours, breast milk 4 hours, a light meal and formula milk 6 hours and a heavy meal up to 9 hours. Reducing gastric acidity is important. Histamine 2 (H2) receptor antagonists and proton-pump inhibitors (PPIs) are commonly used to increase gastric pH, although they do not affect the pH of fluid already in the stomach. An oral agent like 30% sodium citrate solution effectively increases gastric pH above 2.5, but at the same time also increases gastric contents volume and is associated with nausea and vomiting. An oral H2 antagonist 1-2 hours before anaesthesia and a PPI, given in two successive doses 12 hours apart are the most effective regimen to reduce gastric acidity. Prokinetic drugs, the most common of which is metoclopramide, may decrease the risk of aspiration by decreasing the volume of gastric contents. The prokinetic agents improve gastric emptying in the presence of diabetic gastroparesis but do not normalize gastric emptying. Tolerance to H2-receptor antagonists may occur and use of a PPI should be considered in those patients taking certain H2-receptor antagonists. However, the routine administration of the above mentioned drugs has not been recommended by the American Society of Anesthesiologists Task Force on Preoperative Fasting. A recent meta-analysis suggested that ranitidine was superior to PPIs in both reducing gastric fluid volume and acidity.

**Rapid sequence induction**

It has been shown that most cases of aspiration occur on induction of anaesthesia and laryngoscopy. For patients at high risk of aspiration, a Rapid sequence induction (RSI) is the induction of choice unless presented with a sufficiently difficult airway to warrant an awake fibreoptic intubation. The pre-requisite for a RSI is an adjustable tilting trolley with a working hand held suction machine. The technique involves three minutes of pre-oxygenation prior to the administration of an induction agent, cricoid pressure (30 Newtons pressure to close the oesophagus without distorting the airway and to be released in the case of active vomiting to avoid oesophageal rupture and not to be released until confirmation of appropriate placement of the tracheal tube with the cuff inflated) and the rapidly acting muscle relaxant succinylcholine.

**Reducing gastric volume**

A nasogastric tube is very useful to empty the stomach and reducing gastric volume before induction of anaesthesia. Studies have shown that there is no significant difference between the incidence of gastro-oesophageal reflux with large or small bore tubes. A nasogastric tube left in situ during a rapid sequence induction does not interfere with the efficacy of cricoid pressure. In addition, the lumen of the nasogastric tube is thought to provide a passageway for the drainage of gastro-oesophageal contents when effective cricoid pressure is applied.
Airway devices

A cuffed endotracheal tube is considered the gold standard device used for airway protection. It has also been suggested that microaspiration of secretions occurring between the cuff and tracheal mucosa plays a role in ventilator acquired pneumonia in the critically ill. In addition, there is some evidence that applying gel lubrication to tracheal tubes and continuous subglottic aspiration of secretions results in delayed aspiration and onset of ventilator-associated pneumonia. More recently an endotracheal tube that uses ‘gills’ as a barrier, rather than an inflatable cuff, has been demonstrated to have excellent efficacy in preventing aspiration.

Alternative supraglottic devices

Alternative supraglottic devices include the classic laryngeal mask airway (LMA) and the proseal LMA. The newer generation SGD like proseal and LMA supreme may be superior to other supraglottic airway devices by providing a higher seal pressure (up to 30 cm H2O) and a drainage channel for gastric contents. Despite other reports of safe use of proseal LMA in large series, there still is concern about the safety of this practice.

Extubation

Patients at risk of aspiration on induction of anaesthesia are similarly at risk on extubation. Care should be taken to ensure that their airway reflexes have fully returned before extubation occurs. Extubation should be done in the left lateral or sitting position.

REFERENCES


42. American Society of Anesthesiologists Committee. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters. Anesthesiology 2011;114:495-511.


