Abstract: Perioperative aspiration into the lungs is an infrequent but potentially serious cause of anesthesia-related morbidity and mortality. It is still a leading cause of death from pulmonary complications. Aspiration occurs in approximately three per 10,000 anesthetic procedures with higher incidences in special patient populations and emergency situations. Any patient with symptoms following aspiration that last for more than two hours in the recovery room should be admitted to an intensive care unit for further observation and therapy. This article reviews incidence, morbidity and mortality of perioperative aspiration as well as risk factors and preventive measures. Among preventive measures the use of drugs designed to increase gastric pH, recent developments in supraglottic airway devices and application of rapid sequence induction with cricoid pressure are discussed. Also, international fasting guidelines and clinical management following aspiration are provided.

Key words: Perioperative pulmonary aspiration; morbidity and mortality; rapid sequence induction; aspiration prophylaxis; fasting guidelines.

Pulmonary aspiration is also a risk in procedural sedation and analgesia as well as during airway management outside the operating room like in the emergency department, in emergencies on the ward as well as in prehospital emergency care. Studies suggest that the risk in emergency intubations outside the operating room is clearly more likely to lead to aspiration and fatal outcomes (7-9) while during procedural sedation where airway manipulation does not routinely take place, aspiration rates seem to be low (10). The anesthesiologist, but also emergency and intensive care physicians as well as other physicians who administer procedural sedation and analgesia or may be involved in emergency intubations should be aware of the risk of pulmonary aspiration.
The primary objective of this article is to provide an update of the literature on incidence, morbidity and mortality of perioperative aspiration as well as the risk factors for the development of aspiration. In addition, preventive measures, international fasting guidelines and the clinical management of aspiration are outlined. The review is based on pertinent English and German literature (clinical studies, meta-analyses, editorials and reviews) which was retrieved by a search in Pubmed from 1990 through July 2011 with the following search terms: “Anesthesia pulmonary aspiration incidence”, “Anesthesia pulmonary aspiration (mortality OR morbidity)”, “Anesthesia pulmonary aspiration risk”, “Anesthesia pulmonary aspiration prophylaxis”, “(Anesthesia OR preoperative) fasting guidelines” “Anesthesia pulmonary aspiration therapy”. In addition, references of articles were screened for additional relevant papers.

**INCIDENCE**

The actual number of aspirations is still unknown as most of the patients who aspirated show no symptoms and thus the diagnosis of aspiration is not made. Primarily the numbers are based on complications occurring after aspiration and not on observed aspirations.

The most extensive retrospective studies on aspiration incidence are the data of Warner et al. (11) with 3.1 and Sakai et al. (12) with 1.4 aspirations in 10,000 anesthetic procedures; however, Sakai et al. used a more stringent definition of aspiration which might explain their lower incidence. Also, the incidence of severe complications and death rates clearly declined over time (12). Another retrospective study reports the incidence of aspiration in adults and children and thus ensures comparability: in children aspiration occurred with 2.28/10,000 anesthetic procedures twice as much as in adults with 1.15/10,000 (13). In other studies the incidence rates in children are not so consistent: Assuming an incidence rate of one to three aspirations in 10,000 anesthetic procedures in adults (11, 12), Borland et al. (14) and Murat et al. (15) found a two- to threefold increase in children, while others did not find an increased incidence rate (16-18).

The most comprehensive prospective observational studies are those of Møller-Olsen et al. (19), Charuluxananan et al. (20) and Punjasawadwong et al. (21), the latter in ambulatory patients in hospitals. They all report aspiration incidences between 2.6 and 2.9/10,000 anesthetic procedures.

**Special patient groups**

Emergency procedures are associated with a higher frequency of aspiration than are elective procedures. The incidence ranges from a four-fold increase (11, 19) to a 12-fold increase (17).

In obstetric and gynecological surgery Sørøide et al. (22) report an incidence of 4.3 aspirations in 10,000 anesthetic procedures; however, they included only patients with clinical symptoms of pneumonitis. Other studies report 5.3 (23), 6.5 (24) or 9.1 aspirations (25) in 10,000 anesthetic procedures. Especially in obstetric patients more contemporary data are needed, as more regional anesthesia techniques are used (26, 27) and increasingly morbidly obese parturients pose new challenges to the anesthesiologist (28, 29).

Other studies comprise very small and special patient populations. In some of them no aspiration occurred (16, 30-33), in others the aspiration incidence was notably increased, e.g. when intubation difficulties (34) or laryngospasm (35) occurred, and after bariatric surgery (36) and esophagus resection (37). In patients who underwent bariatric surgery esophageal dysmotility and gastro-esophageal reflux are not uncommon (38). After esophagus resection patients are at a higher risk for perioperative pulmonary aspiration due to loss of the esophageal sphincter and altered neck anatomy with the proximal part of the esophagus lying laterally to the cricoid cartilage, so that cricoid pressure can only effectively be applied in modified form on the esophagus anastomosis or proximally of the anastomosis on the visible scar at the inner border of the left sternocleidomastoid muscle (39-41).

**Morbidity and mortality**

Aspiration of gastric content can lead to a range of diseases such as aspiration pneumonia, aspiration pneumonitis and ARDS (5, 42, 43). Aspiration pneumonia is an infectious process caused by aspiration of oropharyngeal secretion that is colonized by pathogenic bacteria. It occurs predominantly as an unwitnessed event in elderly patients with dysphagia and gastric dysmotility (5), but also due to silent aspiration in intensive care patients with long-term ventilatory support despite the use of cuffed tubes (42). Typical symptoms of aspiration pneumonia are tachypnea, cough, and signs of pneumonia. In contrast, aspiration pneumonitis is defined as acute lung injury after the aspiration of regurgitated gastric content (5). It is often a wit-
nased event. A bacterial infection at a later stage is possible. Its symptoms may range from no symptoms or symptoms ranging from a non-productive cough to tachypnea, bronchospasm and pulmonary edema, hypotension and hypoxemia with rapid progression to severe acute respiratory distress syndrome (ARDS) (5).

In children morbidity is lower (17, 44) and there has been no published lethal outcome for more than 30 years (14, 45). However, older patients over 80 years have a 6.3-fold increased risk for aspiration pneumonia compared to 18 to 29 year old patients (46). In a retrospective study of 99,441 anesthetic procedures with 14 cases of confirmed perioperative pulmonary aspiration it was shown that morbidity and mortality occurred only in ASA patient status III and IV (12). Another study showed that patients with clinically apparent aspiration who do not develop symptoms within the first two hours after aspiration are unlikely to show adverse respiratory consequences (11).

The mortality rate after aspiration varied in three large retrospective studies between 7.1% (12), 4.5% (11) and 3.8% (47). Also, based on data of the Confidential Enquiry into Maternal Deaths in the UK, there has been a continuous decrease in obstetric anesthesia death rates after pulmonary aspiration (48). An analysis of deaths in the perioperative period in 1999 in France showed that from 131 cases related to respiratory complications 83 cases (63%) were related to aspiration of gastric content (49). Newly published data from the Royal College of Anaesthetists and the Difficult Airway Society showed that aspiration of gastric content was the most common cause of airway-related mortality during anesthesia (4). They analyzed 133 major pulmonary complications in estimated 2.9 million anesthetic procedures over a period of one year in all National Health Services (NHS) hospitals. Aspiration occurred in 23 anesthesia cases and accounted for eight deaths and two cases of brain damage and was the most common cause of anesthesia airway-related mortality. However, the authors assume that based on statistical analysis of the distribution of reports probably only as few as 25% of relevant incidents may have been reported.

RISK FACTORS

The most consistent risk factors in retrospective analyses are emergency cases (11, 47), high ASA physical status grades (11, 14), esophageal pathology (12), previous esophageal surgery (11, 12), gastrointestinal obstruction or dysfunction (11, 12, 47), depressed level of consciousness (12), a recent meal and delayed gastric emptying (11), concurrent opioid medication (12, 47) and obesity (12, 47). Other according to anesthesia textbooks mentioned risk factors like diabetes mellitus, age and positioning were only rarely mentioned as such (14, 47, 50-52). Remarkably few prospective studies are published on the risk factor obesity (53, 54). However it should be noted, that even the absence of predisposing conditions should not give the anesthesiologist a false sense of security, as in the study of WARNER et al. (11) half of the aspirations showed no predisposing conditions.

During anesthesia reflux is a common risk factor for aspiration. A decrease of the lower esophageal sphincter tone by drugs (anticholinergics, opioids, thiopental and volatile anesthetics) and consequent reduction in the gastro-esophageal pressure gradient promotes gastro-esophageal reflux and may increase the aspiration risk (2). In addition, aspirations and other adverse postoperative respiratory events can be the consequence of unnoticed incomplete neuromuscular recovery (55).

TOTAL GASTRIC VOLUME AND pH

In retrospective studies gastric volume or acidity is usually not known, as in clinical practice they cannot be measured routinely by non-invasive measurement in the perioperative period. The few prospective studies on gastric volume and acidity without the administration of drugs for aspiration prophylaxis are those of HARDY et al. (56) and SCHWARTZ et al. (57). In both there was no correlation between gastric volume and incidence of gastro-esophageal reflux as a surrogate marker. Moreover, a prospective study in overweight and obese paediatric patients showed that there was no increased gastric fluid volume (GFV) after 2-h preoperative clear liquid fast (58). Thus, there is still no evidence that demonstrates a linkage between GFV and an increase in risk of pulmonary aspiration or even a dose-response relationship between GFV and aspiration risk (59). Maybe in the near future gastric sonography as a diagnostic tool can provide reliable information to assess the nature and volume of gastric content preoperatively especially in emergency patients and certain medical conditions with delayed gastric emptying (60, 61).

Even though a dose-response relationship would be a good piece of evidence for a causal relationship between GFV and aspiration risk, this
would not preclude the presence of confounders. It does not reduce its usefulness as a marker. However it means, that its removal would not reduce the increased risk which is associated with it, whereas a risk factor could possibly be neutralized by prophylactic measures. For this reason, more investigations should be performed on the dose-response relationship of gastric fluid volume and aspiration while differentiating between risk factor and marker.

Change in perspective

There is consensus in the literature that the traditionally used cut-off-value of gastric fluid volume $> 25 \text{ ml}$ and $\text{pH} < 2.5$ based on a rhesus monkey experiment by Roberts and Shirley (62) is not evidence-based and should no longer be used to be indicative of an increased risk of pulmonary aspiration (59). Schreiner already wrote in 1998 on the occasion of the 25th year of the appearance of this classical article in Anesthesia & Analgesia “Perhaps the most appropriate response to the celebration of the 25th anniversary of the publication of this highly influential article would be to finally lay to rest the myth it created” (59). In addition, the volume of fluid aspirated into the lungs does not necessarily correlate with gastric volume, so that extrapolating from one volume on the other should be investigated in further studies. Schreiner therefore recommends shifting the focus from GVF at the time of induction of anesthesia to the patients’ characteristics and comorbidities as well as to anesthetic practices that put patients at risk of pulmonary aspiration.

LARYNGEAL MASK AIRWAY (LMA)

Supraglottic airway devices have become increasingly important in airway management over the past years. Several publications deal with the regurgitation and aspiration risk of the laryngeal mask airway (63-67) and newer airway devices such as the ProSeal laryngeal mask airway (68-70), the stream-lined pharynx airway SLIPA™ (71), the cuffed oropharyngeal airway (72) and the Combitube (73). One study compares the supraglottic airway devices laryngeal mask airway (LMA)-Classic™, LMA-ProSeal™, Ambu AuraOnce and Intersurgical i-gel in groups of 40 patients also with respect to the aspiration risk (74). Airway morbidity was not observed in any group. There is only one meta-analysis from 1995 on the incidence of aspiration associated with the laryngeal mask airway (75): There were three cases of aspiration in 12,901 patients. Thus, according to the evidence they concluded that aspiration with the LMA seems uncommon and comparable to that for outpatient anesthesia with the face mask and tracheal tube. However, the authors stress the importance of meticulous attention to selection of low-risk patients and appropriate operative procedures as well as avoidance of light anesthesia (75). In 2004 Brimacombe et al. (76) report three own cases of aspiration with the LMA, resulting in one death and one patient with brain damage and Asai (77) stated in an editorial to the article that there may be a considerable number of unreported deaths with LMA. The true incidence of aspiration with LMA could only be found out if a confidential database were created (78, 79). However, this database should cover all airway devices to allow comparison of the frequency of aspiration among different airway devices (79). In 2009 a large retrospective study comprising 65,712 procedures involving anesthesia delivered via a LMA or tracheal tube was published (67). Aspiration with LMA occurred in three cases from 35,630 procedures (elective surgery : 1/17,349, unplanned surgery 1/933) and with tracheal tube in seven cases from 30,082 procedures (elective surgery : 1/13,819, unplanned surgery 1/489). This shows that the main factor associated with pulmonary aspiration was emergency surgery. Also, in properly selected patients LMA was not associated with an increased risk of aspiration. Clearly more studies are needed to evaluate the risk of pulmonary aspiration with the newer supraglottic airway devices.

Prognostic scores

Some authors favour the development of a prognostic aspiration risk score in order to describe the individual risk profile (42). Indeed, in 2010 in a large prospective, multicenter study a risk index for the prediction of postoperative pulmonary complications with seven independent factors was developed (80). The factors are low preoperative arterial oxygen saturation, acute respiratory infection during the previous month, age, preoperative anemia, upper abdominal or intrathoracic surgery, surgical duration of at least two hours, and emergency surgery. The main outcome was the development of at least one of the following : respiratory infection, respiratory failure, bronchospasm, atelectasis, pleural effusion, pneumothorax, or aspiration pneumonitis. Aspiration pneumonitis occurred in nine out of 2,464 (0.4%) surgical patients included in the study.
Also in pediatric anesthesia a risk assessment tool for respiratory complications was developed (81) by collecting data on family medical history of asthma, atopy, allergy, upper respiratory tract infection, and passive smoking. However, it is probably of no relevance as a predictive tool for aspiration.

In addition, studies are needed which try to elicit the importance of a risk factor. This means that in addition to the risk factor itself its prevalence should also be considered. A relatively small risk factor with high prevalence could be responsible for more cases of aspiration than a distinct risk factor, which occurs very rarely.

**Aspiration Prophylaxis**

**Pharmacotherapy**

The studies on pharmacological aspiration prophylaxis make up the largest share of the publications on pulmonary aspiration. They often compare antacids, H2-receptor antagonists, proton pump inhibitors, or prokinetics alone or in combination, different application routes (per os, intramuscularly, intravenously, rectally), application on the day of surgery and/or the evening before surgery, different dosages and the time until their onset of action. Some studies are limited to special patient groups e.g. patients after esophagus resection (82) and patients with diabetes mellitus (83).

In most studies the effect of the drugs on the surrogate endpoints gastric fluid volume and acidity has been investigated, without referring to the causality between gastric volume and its acidity on the one hand and the aspiration risk on the other hand. Thus the fundamental question remains to what extent antacids, H2 antagonists, and gastroskinetic drugs or their combinations prevent aspirations and reduce morbidity and mortality. Up to now there is no clear evidence to support the existence of a relationship. There is one Cochrane review on 22 studies involving 2658 women, all having a cesarean section under general anesthesia (84). According to the authors the quality of the evidence was poor. But the findings suggest that the combination of antacids plus H2 antagonists was more effective than no intervention, and superior to antacids alone in preventing low gastric pH. However, none of the studies assessed potential adverse effects or focused on clinical outcome parameters. Another meta-analysis on the effectiveness of routine prophylaxis of antacids, H2-receptor antagonist, dopamine antagonists and proton-pump inhibitors for women in normal labour comprises only three trials which however assessed vomiting as endpoint and not the incidence of gastric aspiration (85).

**Rapid sequence induction (RSI)**

RSI is used when general anesthesia must be given in spite of a significant risk of pulmonary aspiration of gastric content (86) (Table 1). In 2007 an evidence-based review article on the impact of RSI and its components on the incidence of aspiration was published: As the rare event of aspiration was not used as outcome parameter in the studies, the authors concluded that because of the lack of evidence its use could neither be supported nor discouraged. They suggest further evidence-based evaluation of the components of RSI (87). Also other authors stress in comprehensive reviews of the literature that cricoid pressure is a not evidence-based, but clinically widespread used measure (42, 93, 94) and they give recommendations for its use in routine and complex situations (87, 89). Because of multiple adverse effects resulting in difficult ventilation and increased inspiratory pressure as well as intubation difficulty, it is important to be aware of the increased risk associated with RSI (94). The goal for rapidly securing the airway by intubation is to achieve an adequate depth of anesthesia and relaxation.

In pediatric patients with full stomach the classical adult type RSI and the routine use of cricoid pressure are not suitable (95). In a controlled randomized simulator-based study comparing two different RSI techniques, classic and controlled in an infant, the authors found that the reduction of haste in RSI-controlled compared with RSI-classic reduces the incidences of unsafe actions as well as the providers’ stress levels and thus increases patient safety (96).

**Guidelines and recommendations**

From „Nil per os“ to the fasting guidelines

Already 20 years ago there was a growing trend to question the validity of the fasting policy „nil per os“ beginning on the evening before operation and to shift to more relaxed regimens. In 1995, Søreide et al. published a meta-analysis on 12 trials concerning the preoperative uptake of clear fluid (97). They concluded that clear fluid uptake does not increase gastric fluid volume. In 1999 the ASA Task Force published the “Practice Guidelines for Preoperative Fasting”, which have become a
consensus and were followed by other national anesthesiology societies. They were last updated in 2011 (98). The guidelines state that for elective cases, intake of clear fluids is allowed up to two hours before induction, breast milk is permissible up to four hours prior and intake of solids and infant formula should cease six hours before anesthesia. Thereafter two meta-analyses on different fasting regimens (duration, type and volume of permitted intake) for adults (99) and children (100) were published. They also concluded that a shorter time of no preoperative fluid uptake would not increase the aspiration risk. Instead, patients permitted a drink of water preoperatively, had a significantly lower gastric fluid volume than those who followed a standard fasting regimen. Few trials specifically investigated patient populations considered to be at increased risk of regurgitation and aspiration and related morbidity (99).

Guidelines in general also reflect the absence of clear evidence and the state of knowledge by not addressing certain aspects or choosing vague wording. So the Practice Guidelines on Fasting of the ASA do not recommend the routine use of drugs to prevent pulmonary aspiration in patients who have no apparent increased risk. However, there are no recommendations for patients with obviously increased risk. Indeed, the intended patient population for the guidelines is limited to healthy patients of all ages undergoing elective procedures and they do not include women in labour. The guidelines do not apply to patients with coexisting diseases or conditions that can affect gastric emptying or fluid volume (e.g., pregnancy, obesity, diabetes, hiatal hernia, gastro-esophageal reflux disease, ileus or bowel obstruction, emergency care, enteral tube feeding) and patients in whom airway management might be difficult (98). In 2011 the European Society of Anesthesiology (ESA) has released its first guideline on preoperative fasting (101). It increases the emphasis on encouraging patients not to avoid fluids for any longer than is necessary and it offers practical, pragmatic advice on chewing gum, smoking and drinks containing milk. For emergency procedural sedation the American College of Emergency Physicians (ACEP) has published a consensus-based clinical practice advisory which recommends two hours for clear liquids, like ASA, but three hours for all other oral intake (102). In the UK there exists no pre-procedural fasting guideline in emergency sedation; instead, the ASA guidelines designed for general anesthesia are extrapolated to emergency care (10). In children, the American Academy of Pediatrics issued the “Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures” (103). An overview on the existing international guidelines is summarized in Table 2. The table maintains the recommendations as written in the original guidelines.

The guideline recommendations relating to preoperative fasting requirements differ only
### Table 2
Preoperative fasting guidelines

<table>
<thead>
<tr>
<th>Guidelines</th>
<th>Fasting requirements before induction</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>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</td>
<td>For elective surgery under general anaesthesia, regional anaesthesia or procedural sedation/analgesia: - 2 h for clear liquids - 4 h for breast milk - 6 h for industry milk, infant formula, nonhuman milk and light meal - 8 h or more for fried and fatty food and meat</td>
<td>- Limited to healthy patients - Not intended for women in labour and for emergency care - Individual weighing up in patients with diseases or conditions that can affect gastric emptying or in whom airway management might be difficult</td>
</tr>
<tr>
<td>Practice Guidelines for Sedation and Analgesia by Non-Anesthesiologists</td>
<td>- See recommendations by the ASA “Guidelines for Preoperative Fasting” - For urgent or emergent situations, the potential for pulmonary aspiration should be considered when determining the target level of sedation, delay of procedure, or protection of the trachea by intubation</td>
<td></td>
</tr>
<tr>
<td>Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures: An Update</td>
<td>Fasting requirements before elective sedation: See recommendations by the ASA “Guidelines for Preoperative Fasting” Before emergency sedation: - Weighing the risks against the benefits - Use of agents with less risk of depressing protective airway reflexes - In case of required deep sedation protection of the airway may be necessary</td>
<td></td>
</tr>
<tr>
<td>Guidelines to the Practice on Anesthesia</td>
<td>Applicable to all forms of anaesthesia, including procedural sedation: - See recommendations by the ASA “Guidelines for Preoperative Fasting”</td>
<td></td>
</tr>
<tr>
<td>Practice Guidelines for Obstetric Anesthesia</td>
<td>- Modest amounts of clear liquids for uncomplicated labouring patients - Solid foods should be avoided in labouring patients - 2 h clear fluids for elective caesarean delivery; further restrictions, determined on a case-by-case basis, in patients with additional risk factors (e.g. morbid obesity, diabetes, difficult airway) or increased risk for operative delivery - 6-8 h after solids depending on the type of food ingested in scheduled caesarean delivery or postpartal surgery - Consideration of timely administration of nonparticulate antacids, H2-receptor antagonists and/or metoclopramide before caesarean delivery or postpartum tubal ligation</td>
<td></td>
</tr>
<tr>
<td>Pre-operative Assessment - The role of the Anaesthetist (2001)</td>
<td>Based on ASA guidelines: - 2 h clear non-particulate and non-carbonated fluids - 4 h breast milk - 6 h solid food, infant formula, or other milk</td>
<td></td>
</tr>
</tbody>
</table>

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Preoperative fasting before general anaesthesia:
- 2 h water and other clear liquids
- 4 h breast milk
- 6 h formula milk or cows’ milk, sweets, tea/coffee with milk, solid food

- procedures under sedation and regional anaesthesia not covered
- In higher risk patients including those with obesity, diabetes and gastro-oesophageal reflux consider further interventions, as appropriate
- Patients undergoing emergency surgery treat as „full stomach”, if possible, follow normal fasting guidance
- Chewing gum should not be permitted on the day of surgery

Pre-operative Fasting Guidelines
Task Force on Scandinavian Pre-operative Fasting Guidelines, Clinical Practice Committee Scandinavian Society of Anaesthesiology and Intensive Care Medicine (109) 2005 Scandinavia

Guideline valid for adults, children, pregnant women not in labour and elective Caesarean section
- 2 h clear fluids like water, coffee, tea, pulp-free juice and soft drinks, but also preoperative carbohydrate drinks intended for preoperative nutrition
- 4 h breast milk and formula milk
- 6 h solids including soups, yoghurt, sour milk and milk-containing drinks
- 2 h for chewing gum and any form of tobacco
- Up to 1 h prior to induction 150 ml of water in adults and 75 ml in children with oral premedication

- Assessment on an individual basis in patients with known or suspected delay in gastric emptying (e.g. diabetes)
- Fasting in emergency patients cannot secure gastric emptying and should not delay surgical interventions (Fasting will not make them “fasted and elective” due to both the effect of pain per se, the opioids given or gastrointestinal obstruction). The same applies to pregnant women in labour.

Scandinavian clinical practice guidelines on general anaesthesia for emergency situations
Clinical Practice Committee of the Scandinavian Society of Anaesthesiology and Intensive Care Medicine (89) 2010 Scandinavia

Unless the patient has an increased risk of aspiration, patients scheduled for emergency surgery can be considered fasting:
- 2 h clear fluids
- 6 h meal
- In case of a high risk of regurgitation H2-blocker, a proton pump inhibitor or sodium citrate can be used to reduce acidity
- Pre-operative gastric emptying with an oro gastric or a nasogastric tube is rarely indicated

- Change in emphasis: encourage drinking of clear fluids up to 2 h before elective surgery including caesarean section
- Tea or coffee with milk added (up to about one fifth of the total volume) are still clear fluids
- Surgery should not be cancelled or delayed if patient chewed gum, sucked a boiled sweet or smoked immediately prior to induction
- Consider the safety and possible benefits of preoperative carbohydrates
- Advice on postoperative resumption of oral intake

Analgesia and Anaesthesia Practice in Obstetrics
German Society of Anaesthesiology and Intensive Care Medicine (110) 2009 (update of 2004) Germany

Women in labour:
- Small amounts of clear fluid, including carbohydrate drinks or a light meal (exclusion: potential caesarean section)
- No solids

Elective caesarean section:
- 2 h clear fluids
- 6 h solids
- Recommendation of pharmacologic prophylaxis

- limited to elective surgery
- regional anaesthesia not mentioned

Pre-operative fasting in elective surgery
German Society of Anaesthesiology and Intensive Care Medicine (111) 2008 (update of 2004) Germany

- 2 h clear fluids
- 4 h breast milk and formula milk
- 6 h milk-containing drinks
- 6 h solids

Recommendations for pharmacologic prophylaxis:
- no routine use of antacids, metoclopramide or H2-receptor antagonists before elective surgery in non-obstetric patients
- In elective caesarean section: H2-receptor antagonist should be given the night before, and on the morning of the operation
- emergency caesarean section IV H2-receptor antagonist, supplemented with 30 ml of 0.3 mol/l sodium citrate if general anaesthesia is planned

- Change in emphasis: encourage drinking of clear fluids up to 2 h before elective surgery including caesarean section
- Tea or coffee with milk added (up to about one fifth of the total volume) are still clear fluids
- Surgery should not be cancelled or delayed if patient chewed gum, sucked a boiled sweet or smoked immediately prior to induction
- Consider the safety and possible benefits of preoperative carbohydrates
- Advice on postoperative resumption of oral intake

Guideline on preoperative fasting
European Society of Anaesthesiology 2011 (101)

Applicable to children and adults
Patients with obesity, gastro-oesophageal reflux, diabetes and pregnant women not in labour can safely follow the guidelines
- 2 h clear fluids and carbohydrate-rich drinks specifically developed for perioperative use
- 4 h breast milk
- 6 h solids and other milk

Recommendations for pharmacologic prophylaxis:
- no routine use of antacids, metoclopramide or H2-receptor antagonists before elective surgery in non-obstetric patients
- In elective caesarean section: H2-receptor antagonist should be given the night before, and on the morning of the operation
- emergency caesarean section IV H2-receptor antagonist, supplemented with 30 ml of 0.3 mol/l sodium citrate if general anaesthesia is planned

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slightly. While all guidelines endorse a 2-h fasting interval for clear liquids and a 6-h interval for solid meal, some explicitly mention fasting requirements for specific types of intakes like fatty meals, milk, chewing gum and smoking or include more specific recommendations concerning the use of preoperative carbohydrates. The new ESA guideline even clarifies the amount of milk in tea and coffee in order to be still considered clear fluids (up to about one fifth of the total volume).

**Short Notes on Clinical Management Following Aspiration**

Emergency measures

Since the diagnosis of aspiration is made clinically, further actions are dictated by subsequent findings and therapy is usually symptomatic. Emergency measures are outlined in Table 3.

While suctioning the patient, the airway should be secured by endotracheal intubation which permits more adequate airway control, reduces the risk of further aspiration, provides mechanical breaths, and permits higher levels of positive end-expiratory pressure (PEEP) if indicated (42).

Patients who are stable after extubation during a period of two hours in the recovery room (oxygen saturation ≥95%, FiO2 < 50%, heart rate < 100/min, respiratory rate < 20/min in adults), can be transferred to the normal ward (112). Any patient with symptoms and/or signs following an aspiration that last for more than two hours should be admitted to an intensive care unit for further observation and therapy (11).

If particulate matter is aspirated, bronchoscopy should be performed and the particles removed (6). If necessary, a rigid bronchoscope should be considered (112). Aspirate should be ensured for microbiological testing. The measurement of the pH of suctioned material is recommended to determine acidity (42). Radiographic findings may not appear for several hours. Some irregular shadows constitute the most prominent and frequent finding initially. However, a chest radiograph should always be obtained if aspiration is suspected (47).

**Antibiotics, corticosteroids and ventilation**

The routine use of antibiotics for aspiration should be discouraged because it has no obviously positive influence on the clinical outcome (113). Nevertheless, a vast majority of intensive care physicians are prescribing antibiotics in patients with suspected aspiration (6) based on the typical spectrum of organisms suspected in aspiration pneumonia acquired in the particular hospital. However, if bowel content is aspirated following an obstructive or paralytic ileus, antibiotics should be given (6, 43). Penicillin, often combined with β-lactamase inhibitor and clindamycin are used as first-line antibiotics. Alternatively, a combination of a third-generation cephalosporin and clindamycin is used.

Current practice on the use of corticosteroids suggests that they are of no benefit and may in fact worsen the clinical outcome in the event of pulmonary aspiration (6, 42, 43).

If an acute lung injury develops, protective ventilation using pressure-controlled mode of action is required. A tidal volume of 6 ml/kg BW with a plateau pressure ≤30 cm H₂O has been shown to be successful in reducing mortality so that FiO₂, PEEP, respiratory rate and minute volume can be adjusted according to arterial blood gas analysis and airway pressures (114, 115).

**Conclusion**

It is generally accepted that pulmonary aspiration is a rare event in the perioperative period. Nevertheless, aspiration of gastric content is still the most common cause of airway-related mortality during anesthesia. The traditionally used cut-off value of gastric fluid volume and acidity as suggested by Roberts and Shirley is not evidence-based and should no longer be used to be indicative of an increased risk of pulmonary aspiration. We are
advised to shift the focus from gastric fluid volume at the time of induction of anesthesia to the patients’ characteristics and comorbidities as well as to anesthetic practices that put patients at risk of pulmonary aspiration. The risk of aspiration increases with the degree of unconsciousness and especially in emergency surgery. As supraglottic airway devices have become widespread in airway management over the past years, clearly more studies are needed to evaluate the risk of pulmonary aspiration with the newer supraglottic airway devices. However, the true incidence of aspiration could only be found out if a confidential database which covers all airway devices to allow comparison of the frequency of aspiration among different airway devices were created. There is general agreement in the fasting guidelines regarding the 2-h fasting interval for clear liquids and a 6-h interval for solid meal. However, further research with high quality studies is needed especially where the fasting guidelines and recommendations for aspiration prophylaxis remain silent or vague. This is especially true for the cricoid pressure applied as part of RSI. Here, further evidence-based evaluation of the components of rapid sequence induction is suggested. Patients with clinically apparent aspiration who do not develop symptoms within the first two hours after aspiration are unlikely to show adverse respiratory consequences. Any patient with symptoms following an aspiration that last for more than two hours should be admitted to an intensive care unit for further observation and therapy.

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