Review Article:

Pulmonary aspiration of gastric contents: prevention and prophylaxis

Aloka Samantaray
Department of Anaesthesiology and Critical Care, Sri Venkateswara Institute of Medical Sciences, Tirupati

ABSTRACT

Pulmonary aspiration of gastric contents is one of the most fatal complications not only in the scenario of an operating room but also in critically ill patients, who have an increased risk for silently aspirating oropharyngeal secretions and regurgitated gastric contents. Prevention is the key to avoid this feared event. Strict adherence to guidelines regarding fasting in the preoperative period, avoidance of residual muscle paralysis and early return of protective airway reflexes by carefully choosing appropriate anaesthetic agents are corner stones of safe anaesthetic practice. Routine preoperative pharmacoprophylaxis to reduce gastric acidity and volume is not recommended and tolerance to commonly used histamine 2 receptor antagonists may occur and use of proton-pump inhibitors may be necessary. In the critical care arena small-volume clinically silent aspirations of oropharyngeal secretion are more common and head-of-bed elevation has been identified as the single most important factor which can greatly reduce the risk of aspiration and thereby reduce the incidence of ventilator associated pneumonia. Most of the intensivists favours use a continuous enteral feed and checking of correct placement of feeding tube at regular interval to reduce the frequency of pulmonary aspiration of gastric contents. In this review we summarise the pathophysiologic mechanism and predisposing factors to pulmonary aspiration of gastric contents. We will also present evidence for and rationale behind the practices adopted in critical care area and operation theatre setup to prevent aspiration.

Key words: *Anaesthesia, Intensive care, Aspiration, Complications, Prevention, Prophylaxis*

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INTRODUCTION

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.[1] 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.[2]

The North American Summit,[3] 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 content 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.

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Corresponding author: Dr Aloka Samantaray, Additional Professor, Department of Anaesthesiology and Critical Care, Sri Venkateswara Institute of Medical Sciences, Tirupati, India.
e-mail: aloksvims@gmail.com

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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.[17] In two studies,[18,19] 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).[20,21]

After-effects of pulmonary aspiration

The clinical picture following pulmonary aspiration of gastric content may be attributed to the particulate matter, acid and microbiological composition of the aspirate.

Particulate matter related aspiration usually result in acute obstruction of small airways and will lead to distal atelectasis. However obstructions of a large airway often result in sudden arterial hypoxaemia and may prove fatal. Gastric contents are not sterile and is a cause of both community acquired (anaerobes) and hospital acquired pneumonia (mixed aerobes and anaerobes). This occurs either as a result of inhaling infected material or secondary bacterial infection following chemical pneumonitis. It is associated with the usual symptoms of pneumonia such as tachycardia, tachypnoea, cough and fever, and may be evidenced by segmental or lobar consolidation (classically right middle lobe) on the chest radiograph.

The effects of acid aspiration have both an immediate and a delayed onset. The effects of the acid are evident within five seconds of contact and are noted from the trachea to the alveoli. There is loss of ciliated and non-ciliated cells within 6 hours, and regeneration is evident after 3 days and complete in 7 days. There is a release of pro-inflammatory cytokines such as tumour necrosis factor-α and interleukin-8 inducing neutrophil recruitment. There is up-regulation of cell adhesion molecules which cause increased thromboxane and oxygen radical release.[22-25]

Factors predisposing to pulmonary aspiration

The factors that predispose a patient to pulmonary aspiration[26,27] 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.[28] 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 30^0 to 45^0 head-of-bed elevation, unless contraindicated.[29-31] In a multivariate analysis[32] 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 H_2O)[33,34] and it should be ensured that secretions are cleared from above the cuff before it is deflated.[30] Sedatives should be used as sparingly as feasible because their interference with gastric emptying and normal cough clearance mechanism.[35,36] 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.[31] The current level of evidence does not conclusively recommend regarding the best type of formula delivery method (continuous

Table 1: Factors predisposing to pulmonary aspiration

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

ICU = intensive care unit

or intermittent). However, use of continuous feeding over bolus feeding was documented in one study[37] 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.[38,39]

Prevention of aspiration in anaesthesia practice

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

Fasting guide lines 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.[42,43] 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.[44, 45] 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.[46] However, the routine administration of the above mentioned drugs has not been recommended by the American Society of Anesthesiologists Task Force on Preoperative Fasting.[42] A recent meta-analysis[47] 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-requirement 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)[48] 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.[49] 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.[50]

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.[52] In addition, there is some evidence that applying gel lubrication to tracheal tubes[53]and continuous subglottic aspiration of secretions results in delayed aspiration and onset of ventilator-associated pneumonia.[54] 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.[55]

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 H_2O) and a drainage channel for gastric contents. Despite other reports of safe use of proseal LMA in large series,[56-58] there still is concern about the safety of this practice.[59,60]

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

1. Simpson JY. The alleged case of death from the action of chloroform. Lancet 1848;1:175-6.
2. Mendelson CL. The aspiration of stomach contents into the lungs during obstetric anaesthesia. Am J of Obstet Gynecol 1946:52:191-502.
3. McClave SA, DeMeo MT, DeLegge MH, DiSario JA, Heyland DK, Maloney JP, et al. North American Summit on Aspiration in the Critically Ill Patient: consensus statement. JPEN J Parenter Enteral Nutr 2002;26:S80-5.
4. Abdulla S. Pulmonary aspiration in perioperative medicine. Acta Anaesthesiol Belg 2013;64:1-13.
5. Hira HS, Zachariah S, Kumar R. Evaluation of ventilator-associated lower respiratory tract infection and tracheobronchial aspiration of gastrointestinal contents. J Assoc Physicians India 2002;50:1381-5.
6. Warner MA, Warner ME, Weber JG. Clinical significance of pulmonary aspiration during the perioperative period. Anesthesiology 1993;78:56-62.
7. Warner MA, Warner ME, Warner DO, Warner LO, Warner EJ. Perioperative pulmonary aspiration in infants and children. Anesthesiology 1999;90:66-71.
8. Sinnatamby CS. Abdomen. In. Sinnatamby CS, editor. Last's anatomy regional and applied. Edinburgh: Churchill Livingstone; 1999.p.215-320.
9. Cotton BR, Smith G. The lower oesophageal sphincter and anaesthesia. Br J Anaesth 1984;56:37-46.
10. Sinnatamby CS. Head and neck and spine. In: Sinnatamby CS, editor. Last's anatomy regional and applied. Edinburgh: Churchill Livingstone; 1999.p.321-447.
11. Vanner RG, Pryle BJ, O'Dwyer JP, Reynolds F. Upper oesophageal sphincter pressure and the intravenous induction of anaesthesia. Anaesthesia 1992;47:371-5.
12. Vanner RG, Pryle BJ, O'Dwyer JP, Reynolds F. Upper oesophageal sphincter pressure during inhalational anaesthesia. Anaesthesia 1992;47: 950-4.
13. McGrath JP, McCaul C, Byrne PJ, Walsh TN, Hennessy TP. Upper oesophageal sphincter function during general anaesthesia. Br J Surg 1996;83:1276-8.
14. Sundman E, Witt H, Olsson R, Ekberg O, Kuylenstierna R, Eriksson LI. The incidence and mechanisms of pharyngeal and upper esophageal dysfunction in partially paralyzed humans: pharyngeal videoradiography and simultaneous manometry after atracurium. Anesthesiology 2000;92:977-84.
15. Moulton C, Pennycook AG. Relation between Glasgow coma score and cough reflex. Lancet 1994;343:1261-2.

16. Tagaito Y, Isono S, Nishino T. Upper airway reflexes during a combination of propofol and fentanyl anesthesia. Anesthesiology 1998;88:1459-66.
17. Irwin RS, Madison JM, Fraire AE. The cough reflex and its relation to gastroeosphageal reflux. Am J Med 2000;108:73S-8S.
18. McKay RE, Malhotra A, Cakmakkaya OS, Hall KT, McKay WR, Apfel CC. Effect of increased body mass index and anaesthetic duration on recovery of protective airway reflexes after sevoflurane vs desflurane. Br J Anaesth 2010;104:175-82.
19. McKay RE, Large MJ, Balea MC, McKay WR. Airway reflexes return more rapidly after desflurane anesthesia than after sevoflurane anesthesia. Anesth Analg 2005;100:697-700.
20. Murphy PJ, Langton JA, Barker P, Smith G. Effect of oral diazepam on the sensitivity of upper airway reflexes. Br J Anaesth 1993;70:131-4.
21. Erskine RJ, Murphy PJ, Langton JA, Smith G. Effect of age on the sensitivity of upper airway reflexes. Br J Anaesth 1993;70:574-5.
22. Wynne JW, Ramphal R , Hood CI. Tracheal mucosal damage after aspiration. A scanning electron microscope study. Am Rev Respir Dis 1981;124:728-32.
23. Goldman G, Welbourn R, Kobzik L, Valeri CR, Shepro D, Hechtman HB. Tumor necrosis factor-alpha mediates acid aspiration-induced systemic organ injury. Ann Surg 1990;212:513-9.
24. Matthay MA, Rosen GD. Acid aspiration induced lung injury. New insights and therapeutic options. Am J Respir Criti Care Med 1996;154:277-8.
25. Nagase T, Ohga E, Sudo E, Katayama H, Uejima Y, Matsuse T, et al. Intracellular adhesion molecule-1 mediates acid aspiration induced lung injury .Am J Resp Crit care Med 1996;154:504-10
26. Update in anaesthesia. Available at URL:http://update.anaesthesiologists.org/wp-content/uploads/2011/03/Pulmonary-aspiration-of-gastric-contents. Accessed on October 01, 2013.
27. Engelhardt T, Webster NR. Pulmonary aspiration of gastric contents in anaesthesia. Br J Anaesth 1999;83:453-60.
28. American Association of Critical Care Nurses Practice Alert. Prevention of Aspiration. Available at URL:http://www.aacn.org/wd/practice/content/practice%20alerts/aspiration-practice-alert.pcms?pid=1&& menu= practice. Accessed on October 01, 2013.
29. Torres A, Serra-Batlles J, Ros E, Piera C, Puig de la Bellacasa J, Cobos A, et al. Pulmonary aspiration of gastric contents in patients receiving mechanical ventilation: the effect of body position. Ann Intern Med 1992;116:540-3.
30. Tablan OC, Anderson LJ, Besser R, Bridges C, Hajjeh R. Guidelines for preventing health-care—associated pneumonia, 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. MMWR Recomm Rep 2004;53:1-36.
31. Bankhead R, Boullata J, Brantley S, Corkins M, Guenter P, Krenitsky J, et al. Enteral nutrition practice recommendations. JPEN J Parenter Enteral Nutr 2009;33:122-67.
32. Charles MP, Easow JM, Joseph NM, Ravishankar M, Kumar S, Umadevi S. Incidence and risk factors of ventilator associated pneumonia in a tertiary care hospital. Australas Med J 2013;6:178-82.
33. American Thoracic Society; Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med 2005;171:388-416.
34. Lorente L, Blot S, Rello J. New issues and controversies in the prevention of ventilator-associated pneumonia. Am J Respir Crit Care Med 2010;182:870-6.
35. Nishino T. Physiological and pathophysiological implications of upper airway reflexes in humans. Jpn J Physiol 2000;50:3-14.
36. Kao CH, ChangLai SP, Chieng PU, Yen TC. Gastric emptying in head-injured patients. Am J Gastroenterol 1998;93:1108-12.
37. Kocan MJ, Hickisch SM. A comparison of continuous and intermittent enteral nutrition in NICU patients. J Neurosci Nurs 1986;18:333-7.
38. Tolep K, Getch CL, Criner GJ. Swallowing dysfunction in patients receiving prolonged mechanical ventilation. Chest 1996;109:167-72.
39. Skoretz SA, Flowers HL, Martino R. The incidence of dysphagia following endotracheal intubation: a systematic review. Chest 2010;137:665-3.

40. Ng A, Smith G. Gastroesophageal reflux and aspiration of gastric contents in anesthetic practice. Anesth Analg 2001;93:494-513.

41. Kalinowski CP, Kirsch JR. Strategies for prophylaxis and treatment for aspiration. Best Pract Res Clin Anaesthesiol 2004;18:719-37.

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.

43. Moore JG, Christian PE, Coleman RE. Gastric emptying of varying meal weight and composition in man. Evaluation by dual liquid- and solid-phase isotopic method. Dig Dis Sci 1981;26:16-22.

44. Nishina K, Mikawa K, Takao Y, Shiga M, Maekawa N, Obara H. A comparison of rabeprazole, lansoprazole, and ranitidine for improving preoperative gastric fluid property in adults undergoing elective surgery. Anesth Analg 2000;90:717-21.

45. Nishina K, Mikawa K, Maekawa N, Takao Y, Shiga M, Obara H. A comparison of lansoprazole, omeprazole, and ranitidine for reducing preoperative gastric secretion in adult patients undergoing elective surgery. Anesth Analg 1996;82:832-6.

46. Hirota K, Kushikata T. Preanaesthetic H2 antagonists for acid aspiration pneumonia prophylaxis. Is there evidence of tolerance? Br J Anaesth 2003;90:576-9.

47. Clark K, Lam LT, Gibson S, Currow D. The effect of ranitidine versus proton pump inhibitors on gastric secretions: a meta-analysis of randomised control trials. Anaesthesia 2009;64:652-7.

48. Sellick BA. Cricoid pressure to control regurgitation of stomach contents during induction of anaesthesia. Lancet 1961;2:404-6.

49. Ferrer M, Bauer TT, Torres A, Hernández C, Piera C. Effect of nasogastric tube size on gastroesophageal reflux and microaspiration in intubated patients. Ann Intern Med 1999;130:991-4.

50. Vanner RG, Pryle BJ. Regurgitation and oesophageal rupture with cricoid pressure: a cadaver study. Anaesthesia 1992;47:732-5.

51. Salem MR, Joseph NJ, Heyman HJ, Belani B, Paulissian R, Ferrara TP. Cricoid compression is effective in obliterating the esophageal lumen in the presence of a nasogastric tube. Anesthesiology 1985;63:443-6.

52. Young PJ, Ridley SA, Downward G. Evaluation of a new design of tracheal tube cuff to prevent leakage of fluid to the lungs. Br J Anaesth 1998;80:796-9.

53. Blunt MC, Young PJ, Patil A, Haddock A. Gel lubrication of the tracheal tube cuff reduces pulmonary aspiration. Anesthesiology 2001;95:377-81.

54. Kollef MH, Skubas NJ, Sundt TM. A randomized clinical trial of continuous aspiration of subglottic secretions in cardiac surgery patients. Chest 1999;116:1339-46.

55. Reali-Forster C, Kolobow T, Giacomini M, Hayashi T, Horiba K, Ferrans VJ. New ultrathin-walled endotracheal tube with a novel laryngeal seal design. Long-term evaluation in sheep. Anesthesiology 1996;84:162-72.

56. Verghese C, Brimacombe JR. Survey of laryngeal mask airway usage in 11,910 patients: safety and efficacy for conventional and nonconventional usage. Anesth Analg 1996 ;82:129-33.

57. Brimacombe JR, Berry A. The incidence of aspiration associated with the laryngeal mask airway: a meta-analysis of published literature. J Clin Anesth 1995;7:297-305.

58. Verghese C, Smith TGC,Young E. Prospective survey of the use of the laryngeal mask airway in 2359 patients. Anaesthesia 1993;48:58-60.

59. Cooper RM. The LMA, laparoscopic surgery and the obese patient - can vs should: Le ML, la chirurgie laparoscopique et le patient obése - pouvoir vs devoir. Can J Anaesth 2003;50:5-10.

60. Pennant JH, White PF. The laryngeal mask airway:its uses in anesthesiology. Anesthesiology 1993;79:144-63.