Universal NPO Guidelines

Mark A Warner, M.D.
Professor, Department of Anesthesiology
Mayo Clinic College of Medicine
Rochester, Minnesota

A Case

A 95 kg, 34-year-old woman undergoes a laparoscopic tubal ligation. Shortly after endotracheal extubation and during transport to the postanesthesia care unit (PACU), she attempts to cough, gags and vomits. As she is wheeled into the PACU, she is coughing and cyanotic. You quickly reanesthetize and reintubate her. Concerned that she may have aspirated the vomitus into her trachea, you suction her endotracheal tube and find thick bilious secretions.

- **How important is pulmonary aspiration?**
- **What are the risk factors?**
- **What is the role of preoperative fasting?**
- **When does aspiration occur during the perioperative period?**
- **How do you treat pulmonary aspiration?**
- **What went wrong here?**

Perioperative pulmonary aspiration that results in morbidity or morality is a rare event. Three large studies, one retrospective[1] and the other two prospective,[2,3] have documented the low frequency of mortality associated with pulmonary aspiration of gastric contents. In a retrospective study of adult surgical patients who received any sort of anesthetic service, including sedation or regional anesthetics, at the Karolinska Hospital in Stockholm, Sweden during the years 1967-70 and 1975-83, Olsson et al[1] found the incidence of death from aspiration to be 1:35,000. In a prospective study of 215,488 consecutive general anesthetics at the Mayo Clinic during the years of 1985-91, the incidence of death after aspiration was 1:72,000 (Table 1).[2] Although direct comparisons of results from these two studies are problematic, this 50% reduction in death after pulmonary aspiration appears to be a significant improvement over time. A Mayo prospective study of pulmonary aspiration in children found a frequency of aspiration similar to adults, but no child died. In general, outcomes after aspiration in children tend to be better and their recoveries are quicker.

Table 1. Risk of Aspiration-associated Pulmonary Complications and Death after General Anesthesia by ASA Physical Status Classification

ASA Physical Status Classification	Pulmonary Complications*	Death†
I	1/39,865 (1:39,865)	0
II	2/87,471 (1:43,735)	0
III	7/78,714 (1:11,245)	1/78,714 (1:78,714)
IV and V	3/9,438 (1:3,146)	2/9,438 (1:4,719)

Total	**13/215,488 (1:16,576)**	**3/215,488 (1:71,829)**

*Pulmonary complications include adult respiratory distress syndrome, pneumonitis, or pneumonia (with or without positive viral or bacterial identification).
†Death from aspiration-associated pulmonary complications within 6 months of aspiration.

Importance of Pulmonary Aspiration

Based on the information in Table 1, if similar mortality rates were to be found within the U.S. in general, approximately 200 deaths from perioperative pulmonary aspiration would be expected each year. In our largest institutions, i.e., those that perform as many as 50,000 general anesthetics annually, there would be only 1 death from pulmonary aspiration every 18 months. By applying the numbers (1 death per 72,000 general anesthetics) to individual practice settings, an idea can be derived on the anticipated frequency of this event.

Do these figures imply that pulmonary aspiration is not very important? Not at all; serious morbidity and considerable costs are associated with pulmonary aspiration that does not result in death. In the Mayo study, 66 adult patients (1:3,265) were observed to have bilious secretions within their tracheas.[2] Of these, 18 (27%) required intensive care support (Figure 1). Six of these patients needed mechanical ventilation and other supportive measures for more than 24 hours, and three eventually died.

Figure 1

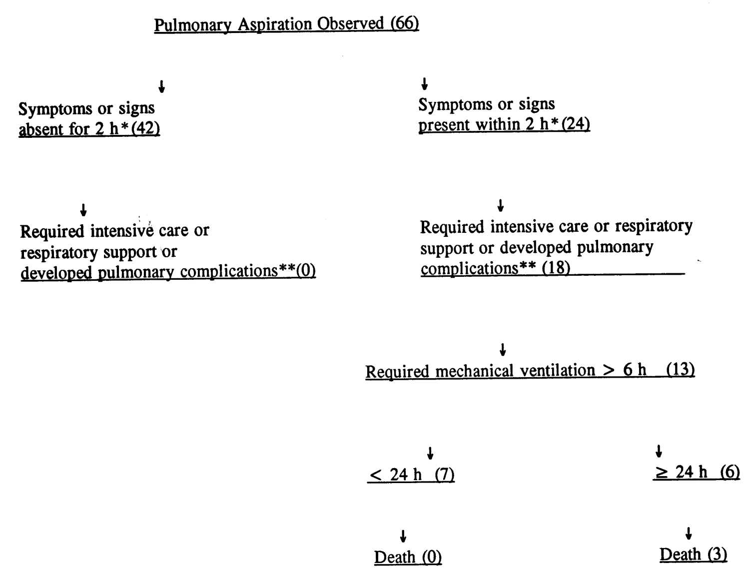


Fig. 1. Relationship of symptoms or signs of pulmonary aspiration that develop within 2 h of aspiration to pulmonary outcomes in 66 patients. * = symptoms or signs of pulmonary aspiration include development of a new cough or wheeze, a decrease in Sp_{O_2} while breathing room air ≥10% less than the preoperative value, alveolar-arterial oxygen tension ≥300 mmHg, and radiographic evidence of pulmonary aspiration; ** = pulmonary complications included development of radiographic evidence of adult respiratory distress syndrome, pneumonitis, or pneumonia (with or without positive viral or bacterial identification).

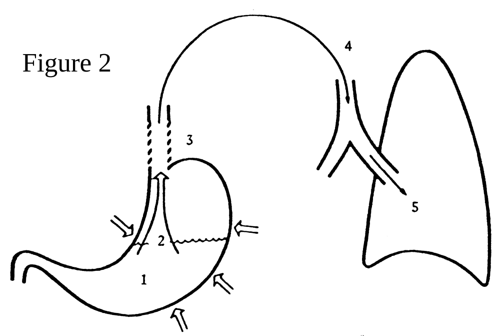
These data suggest that pulmonary aspiration is an important perioperative complication; but the rarity of serious complications raises a question of how much effort and expense we should put into the prevention of aspiration or attenuation of the problems associated with aspiration. Although no exact data are available, surveys of anesthetic practices in the U.S. in 1995 suggested that $10 million was spent that year on prophylactic medications for gastric regurgitation and pulmonary aspiration. The routine use of antacids, histamine (H_2) receptor antagonists, and medications that improve gastric emptying is expensive. Should these medications be used routinely? One interpretation of the low morbidity and mortality rates of pulmonary aspiration within this country is that the routine use of these medications has been effective. However, the data from the Mayo study were obtained in a population in whom there was *not* routine use of these medications. A 1999 report from the ASA Task Force on Preoperative Fasting recommends that no routine prophylaxis be used.[4]

It is clear that medications that are used to decrease gastric contents and/or acidity do as advertised. However, there are no data that suggest that the use of these medications decrease the risk of pulmonary aspiration. Therefore, many studies of the use of medications to reduce gastric volume and acidity have not concluded that they be routinely administered to prevent pulmonary aspiration.[5-9] Will we ever have data that prove the effectiveness of prophylactic medication to prevent pulmonary aspiration? It is unlikely because the number of patients who would have to be studied for this rare event would be both impractical and extremely expensive. All we can say for now is that the incidence of aspiration and serious morbidity is sufficiently low that the cost of preventing one serious complication of pulmonary aspiration by the routine use of these medications would be very high.

Risk Factors for Pulmonary Aspiration

For patients to develop problems associated with pulmonary aspiration, five unique events must occur. Hardy[10] has succinctly simplified these events in Figure 2.

Figure 2



First, the stomach contents must be capable of causing pulmonary damage. In animal models, the amount and type of gastric contents aspirated play a role in determining how much damage occurs to the lungs. In general, the greater the volume and the more acidic and particulate the contents of the stomach that are aspirated, the greater the risk of pulmonary damage. Therefore, medications that empty the stomach or decrease its acidity would be useful to decrease the risk of pulmonary damage if gastric contents ever get into the respiratory system.

Second, the gastric contents must pass from the stomach into the esophagus. The lower esophageal sphincter has both a resting and active tone that inhibits gastric contents from passing retrograde into the esophagus. Increased abdominal pressure from a large mass (e.g.: a pregnant uterus), increased gastric contents (e.g.: after a meal or secondary to a bowel obstruction), or abdominal wall contraction (e.g.: during gagging or coughing) may push stomach contents past the lower esophageal sphincter and into the esophagus. An incompetent esophageal sphincter associated with a hiatal hernia increases the opportunity for stomach contents to pass into the esophagus.

Third, the stomach contents (now in the esophagus) must pass into the pharynx. During induction of anesthesia, anesthesia providers often push posteriorly on the trachea's cricoid cartilage to prevent gastric contents, if present in the esophagus, from passing retrograde into the pharynx. However, they rarely do this maneuver at the end of an anesthetic because posterior cricoid pressure may cause a partially-obtunded patient to gag (thereby increasing abdominal pressure). The opportunity to prevent passage of gastric contents from the esophagus into the pharynx is usually missed for this reason in the postanesthetic period.

Fourth, stomach contents that reach the pharynx must pass through the larynx. In normal conditions, our laryngeal reflux prevents materials from passing the larynx. However, patients who are sedated or obtunded, or who may not have reattained complete control or return or laryngeal muscle function or swallowing reflexes may be at risk for letting pharyngeal contents pass the larynx. Advocates of awake endotracheal extubation often note that the return of the laryngeal reflux and full motor strength are primary reasons for awake extubation.

Finally, gastric contents that pass the larynx into the respiratory system must have sufficient volume or content to cause pulmonary damage. In general, the more acidic the contents, the less volume it takes in the lungs to cause damage. Vise versa, the less acidic, the more volume it takes to cause lung damage. The traditional “rule of thumb” it that the chance of lung damage is most likely if the aspirated material has a pH < 2.5 or a volume > 25 ml. The data that led to this “rule of thumb” have been obtained in animal models, and it is increasingly clear that they do not apply to our patients. Numerous case reports suggest that patients can develop lung problems even when these pH and volume values are not present in the aspirated material.

The risk factors associated with pulmonary aspiration can be divided into general and specific areas (Table 2). For example, elderly patients, especially those greater than 65 years of age, have a greater incidence of pulmonary aspiration than younger patients.[1] The risk of aspiration has been variably reported to be greater in females compared to males,[11,12] but this potential factor has not been consistently reported and is, therefore, suspect. There has been debate about the impact of labor in parturients, especially those in the upper end of body mass index, on gastric emptying and risk of pulmonary aspiration. Two recent studies by Wong et al augment earlier data in finding that both non-obese and obese parturients have normal gastric emptying of clear liquids.[13,14] In many studies, the most predictive risk factors are general health and emergency vs elective anesthetics.[11, 12,15]

Table 2. Anecdotal Risk Factors for Pulmonary Aspiration

General Risk Factors	Specific Risk Factors
Age (older > younger)	Recent oral intake
Gender (female > male)	Opioid administration
Co-morbid diseases	Gastrointestinal obstruction or dysfunction
IDDM	Obesity
CNS deficits	Depressed level of consciousness
Peripheral vascular disease	Previous esophageal dysfunction
Hepatobiliary/gastrointestinal diseases	Head injury or neurologic dysfunction
Renal dysfunction	Lack of coordination of swallowing and Respiration
	Procedures that increase intraabdominal

	Pressure

In 119,351 ASA physical status I and II patients who had elective surgery in the Mayo study, only 1:8,000 had any evidence of pulmonary aspiration, and none of these patients developed serious sequelae or required intensive care support (Table 3).[2] In contrast, 1:1,048 of the 9,438 ASA physical status IV and V patients who had elective or emergency surgery aspirated. The differences in rate of aspiration between the lowest and highest risk patient groups is startling: 1:9,229 in ASA I patients undergoing elective procedures vs 1:343 in ASA IV/V patients undergoing emergency procedures and anesthetics.

Table 3. Risk of Pulmonary Aspiration in Elective and Emergency General Anesthetics by ASA Physical Status Classification

ASA Physical Status Classification	Elective	Emergency	P*
I	4/36,916 (1:9,229)	1/2,949 (1/2,949)	.319
II	11/82,435 (1:7,494)	3/5,036 (1:1,679)	.043
III	31/74,301 (1:2,397)	8/4,413 (1:552)	<.001
IV and V	6/8,409 (1:1,401)	3/1,029 (1:343)	.066
Total	52/202,061 (1:3,886)	15/13,427 (1:895)	<.001

*Comparing emergency to elective anesthetics by Fisher's exact test.

Preoperative Fasting – How Much, When, and What

Why fast at all? Pulmonary aspiration has been considered to be a major cause of intraoperative death starting in 1848 with the demise of Hannah Greener, presumably by pulmonary aspiration although there is debate on this issue.[16] The report of this death and subsequent similar events led to strong recommendations to keep stomachs empty overnight before surgery. Despite these recommendations, it was clear that there were problems associated with prolonged fasting, especially dehydration and its impact on the circulation during anesthesia. In 1883 Joseph Lister suggested in Holmes' famous textbook, Systems of Surgery, that, **"While it is desirable that there should be no solid matter in the stomach when chloroform is administered, it will be found very salutary to give a cup of tea or beef-tea about two hours previously."** Isn't it remarkable that it took nearly a century for us to re-embrace this sage recommendation?

Numerous studies now confirm that clear liquids in children and adults are either effective in decreasing gastric volume and increasing its pH or have no negative impact on these parameters.[17-25] Based on these and numerous other studies, in 1999 the ASA Task Force on Preoperative Fasting made several recommendations on fasting that markedly reduced the length of fasting from clear liquids (Table 4).[4] Gratifyingly, the rate of perioperative aspiration in children does not appear to have increased when there was a change in practice of nothing by mouth (NPO) from midnight until surgery to one of clear liquids to within 2 hours of anesthesia and surgery.[3,26]

Table 4. Summary of Fasting Recommendations to Reduce the Risk of Pulmonary Aspiration

Ingested Material	Minimum Fasting Period (h)
Clear liquids	2
Breast milk	4
Infant formula	6
Non-human milk	6
Light meal	6

At most (but not all) facilities that provide anesthesia services, fasting guidelines now allow clear liquids to within 2 hours of anesthesia and surgery in both children and adults.[26] Curiously, many of the surgeons, proceduralists, and anesthesia providers at these same institutions don't implement the guidelines. Why? In many cases, it is easier to tell patients to refrain from any oral intake after midnight – convenience and clarity of instruction keep the old "NPO after midnight" going strong. For healthy adult patients, this is probably OK. However, there are benefits to drinking clear liquids in the hours before anesthesia. These include:

- *Adequate hydration in infants and small children.* Dehydration has more impact in little kids than in adults. In addition, most are much happier if given clear liquids, especially those with sugar such as clear juices, in periods less than the typical 8 or more hours of fasting between midnight and surgery time. For those of you who as adults have waited into the early afternoon for a delayed surgical procedure, you also will understand that impact of prolonged fasting on irritability.

- *Flushing acids and other gastric contents past the pyloric sphincter.* Clear liquids stimulate gastric peristalsis and churning, causing forward propulsion of gastric contents. In effect, clear liquids "flush" the stomach and for periods of several hours reduce the content of any gastric contents.

- *Dilution of acids.* Clear liquids typically are pure water or flavored water. Therefore, the pH of most clear liquids is near neutral. Ingested clear fluids dilute the acidity of any gastric contents, raising pH, and reducing the risk of pulmonary damage should aspiration occur.

- *Opportunities for caffeine lovers.* For people who are used to drinking significant amounts of caffeine via regular consumption of coffee, tea, or sodas, fasting can cause acute caffeine withdrawal. This problem leads to irritability, headache, decreased pain tolerance, and even nausea. At Mayo Clinic, we encourage many of our patients to drink clear liquids up to 2 hours before their procedures. More specifically, we actively encourage people who regularly consume caffeine to have a cup of coffee (without milk products – sugar and sweeteners are fine) or soda before their procedures. While we don't push them to drink large volumes, we typically do not limit their intake if they want a second cup of coffee, a second soda, or another glass of water or juice. Large volumes of clear liquids are cleared from the stomachs of healthy people in less than one hour.

Timing of Occurrence of Aspiration in the Perioperative Period

Although aspiration may occur at any time (including immediately before the induction of anesthesia), the majority of aspirations appear to occur during tracheal intubation and extubation. A factor commonly found in patients who aspirate when an endotracheal tube is being used is inadequate muscle relaxation. During laryngoscopy in an inadequately paralyzed patient, the patient may gag and vomit. The same sequence occurs during extubation in a patient that is either weak or not alert and responsive. There are a number of very large series that provide variable outcomes on the effectiveness of laryngeal mask airways to prevent aspiration. Some claim remarkably low pulmonary aspiration rates in patients who have one or more risk factors for increased frequency of this problem, but others are equivocal. There are case reports of aspiration with LMA use in both high and low risk patients. At my institution, we believe that it is prudent to avoid their use in patients with predisposing risk factors for aspiration (Table 2), including procedures that increase intraabdominal pressure (e.g.: laparoscopies).

Treatment of Pulmonary Aspiration

Treatment generally consists of supportive respiratory therapy (Table 5). The most important, and the first response directed toward patients who appear to have aspirated is to provide supplemental oxygen. The amount of respiratory support depends on the ability of patients to support ventilation, the severity of the pulmonary aspiration, and its effects on the lung. For patients who have their tracheas intubated, the upper respiratory tree should be suctioned in an effort to remove as much aspirated volume as possible. If particular material is found in the suctioned aspirate, bronchoscopy should be performed in order to remove any large pieces of particulate material. Prophylactic antibodies and steroids are not warranted. Broad spectrum antibiotics may, in fact, prevent early identification of pathogens if bacterial lung damage subsequently occurs. By suppressing the immune response, steroids may increase the risk of pulmonary infection. Tracheal secretions should be cultured to identify potential pathogens.

Table 5: Treatment of Pulmonary Aspiration
Support respiration and oxygenation
Suction trachea and bronchi (but do not instill saline)
Bronchoscope if particulate matter is suspected
Prophylactic antibiotics and steroids are not warranted
Culture tracheal secretions; antibiotics if positive
Continue supportive respiratory therapy

Caveats: Is it necessary to admit outpatients who appear to have aspirated? Do all patients who appear to have aspirated need to be admitted to an intensive care unit? In the Mayo study, patients who were found to have bilious secretions in their tracheas but who were asymptomatic for cough or wheezing, had an unchanged chest x-ray, and were not hypoxemic within 2 hours of the aspiration did not develop any postoperative problems or need respiratory support.[2] Although there will undoubtedly be some patients who are asymptomatic and who will eventually develop pulmonary problems, this evidence suggests that most can be either sent home (if previously scheduled for ambulatory procedures) or admitted to a regular hospital bed.

Review of the Example Case

In the case noted at the start of this manuscript, a variety of factors played a role in her pulmonary aspiration. First, her trachea was extubated while she was still partially anesthetized, and before she had full return of her swallowing and laryngeal reflexes. Second, her intra-abdominal pressure was increased by the injected carbon dioxide during the laparoscopy, and she spent part of her surgery in a head-down position. When combined with her mild obesity, this elevated intra-abdominal pressure increased the risk of her gastric contents passing into her esophagus during the procedure. Third, she coughed and gagged during transport to the PACU. As a result, her abdominal pressure increased acutely and markedly raised the chance of her gastric contents passing up the esophagus and into the pharynx.

After the event, no particulate matter in the material suctioned from her mouth and pharynx was noted, and she did not undergo bronchoscopy. The pH of the bilious secretions suctioned from her trachea was 3.4, not below the mystical pH of 2.5 noted by Mendelson[27] in his original description of pulmonary aspiration, but it was still fairly acidic. The volume of material that could be suctioned from her trachea was less than 2 mL. Treatment was supportive with oxygen and mechanical ventilation. Her tracheal secretions were cultured and checked for infectious agents, but none were found. She was not placed on wide-spectrum antibiotic coverage, and steroids were not used. Her oxygenation improved in the next 2 hours, and she was extubated in the PACU. She received supplemental oxygen during the next 24 hours and was discharged from the hospital the day after her surgery.

This case is presented to exemplify some of the risk factors and treatment possibilities that must be considered. With attention to details and appropriate anticipation of potential problems, few of these cases will occur.

References

1. Olsson GL, Hallen B, Hambraeus-Jonzon K: Aspiration during anaesthesia: a computer-aided study of 185 358 anaesthetics. Acta Anaesthesiol Scand 30:84-92, 1986

2. Warner MA, Warner ME, Weber JG: Clinical significance of pulmonary aspiration during the perioperative period. Anesthesiology 78:56-62, 1993

3. Warner MA, Warner ME, Warner, DO, Warner LO, Warner EJ: Perioperative pulmonary aspiration in infants and children. Anesthesiology 90:66-71, 1999

4. American Society of Anesthesiologists Task Force on Preoperative Fasting: Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: Application of healthy patients undergoing elective procedures. Anesthesiology 90:896-905, 1999

5. Moir DD: Cimetidine, antacids, and pulmonary aspiration. Anesthesiology 59:81-83, 1983

6. Manchikanti L, Kraus JW, Edds SP: Cimetidine and related drugs in anesthesia. Anesth Analg 61:595-608, 1982

7. Joyce TH III: Prophylaxis for pulmonary acid aspiration. Am J Med 83:46-52, 1987

8. Kowalsky SF: Cimetidine in anesthesia: does it minimize the complications of acid aspiration? Drug Intell Clin Pharm 18:382-389, 1984

9. Tompkinson J, Turnbull A, Robson G, et al: *Report on Confidential Enquiries into Maternal Deaths in England and Wales 1973-1975.* London, England: Her Majesty's Stationery Office; 80-81, 1979

10. Hardy JF: Large volume gastro-esophageal reflux: a rationale for risk reduction in the perioperative period. Can J Anaesth 35:162-173, 1988

11. Green NM, Bannister WK, Cohen B, et al: Survey of deaths associated with anesthesia in Connecticut. Conn Med 23:512-518, 1959

12. Harrison GG: Death attributable to anaesthesia. A l0-year survey (1967--1976). Br J Anaesth 50:1041-1046, 1978

13. Wong CA, Loffredi M, Ganchiff J, Zhao J, Wang Z, Avram MJ: Gastric emptying of water in term pregnancy. Anesthesiology 96:1395-1400, 2002

14. Wong CA, Firtzgerald P, Raikoff K, Avram MJ: Gastric emptying in obese term pregnant women. Anesthesiology 99:A1213, 2003

15. Hovi-Viander M: Death associated with anaesthesia in Finland. Br J Anaesth 52:483-489, 1980

16. Knight PR, Bacon DR: An unexplained death: Hannah Greener and chloroform. Anesthesiology 96:1250-1253, 2002

17. Coté CJ: NPO after midnight for children--a reappraisal. Anesthesiology 72:589-592, 1990

18. Litman RS, Wu CL, Quinlivan JK: Gastric volume and pH in infants fed clear liquids and breast mild prior to surgery. Anesth Analg 79:482-485, 1994

19. Schreiner MS, Triebwasser A, Keen TP: Ingestion of liquids compared with preoperative fasting in pediatric outpatients. Anesthesiology 72:593-597, 1990

20. Tomomasa T, Hyman PE, Itoh K, et al: Gastroduodenal motility in neonates: response to human milk compared with cow's milk formula. Pediatrics 80:434-438, 1987

21. Read MS, Vaughan RS: Allowing pre-operative patients to drink: effects on patients' safety and comfort of unlimited oral water until 2 hours before anaesthesia. Acta Anaesthesiol Scand 35:591-595, 1991

22. Cook-Sather SD, Harris KA, Chiavacci R, Gallagher PR, Schreiner MS: A liberalized fasting guideline for formula-fed infants does not increase average gastric fluid volume before electrive surgery. Anesth Analg 96:965-969, 2003

23. Cavell B: Gastric emptying in infants fed human milk or infant formula. Acta Paediatr Scand 70:639-641, 1981

24. Cavell B: Gastric emptying in preterm infants. Acta Paediatr Scand 68:725-730, 1979

25. van den Driessche M, Peeters K, Marien P, Ghoos Y, Devlieger H, Veereman-Wauters G: Gastric emptying in formula-fed and breast-fed infants measured with the ^{13}C-octanoic acid breath test. JPGN 29:46-51, 1999

26. Ferrari LR, Rooney FM, Rockoff MA: Preoperative fasting practice in pediatrics. Anesthesiology 90:978-80, 1999

27. Mendelson CL: The aspiration of stomach contents into the lungs during obstetric anesthesia. Am J Obstet Gynecol 52:191-205, 1946