Anesthesiology
78:56–62, 1993

Clinical Significance of Pulmonary Aspiration during the Perioperative Period

Mark A. Warner, M.D., Mary Ellen Warner, M.D.,† Joseph G. Weber, M.D.‡*

Background: **Pulmonary aspiration of gastric contents during the perioperative period may be associated with postoperative mortality or pulmonary morbidity. Recent determination of the incidence of perioperative pulmonary aspiration and evaluation of factors related to clinical outcomes is lacking.**

Methods: **We retrospectively reviewed the perioperative courses of 172,334 consecutive patients 18 yr of age or older who underwent 215,488 general anesthetics for procedures performed in all surgical specialties from July 1985 to June 1991. Pulmonary aspiration was defined as either the presence of bilious secretions or particulate matter in the tracheobronchial tree or, in patients who did not have their tracheobronchial airways directly examined after regurgitation, the presence of an infiltrate on postoperative chest roentgenogram that was not identified by preoperative roentgenogram or physical examination.**

Results: **Pulmonary aspiration occurred in 67 patients (1: 3,216 anesthetics). Fifteen aspirations occurred in 13,427 (1: 895) anesthetics of patients undergoing emergency surgery, and 52 occurred in 202,061 (1:3,886) anesthetics of patients undergoing elective surgery ($P < .001$). Of the 66 patients who survived their surgery, 42 (64%) did not develop a cough or wheeze, a decrease in arterial hemoglobin oxygen saturation while breathing room air >10% less than the preoperative value, or radiographic abnormalities within 2 h of aspiration. These 42 patients had no respiratory sequelae. Of the 24 patients who had one or more of these findings, 13 required mechanical ventilatory support for more than 6 h. Three of the six patients whose lungs required mechanical ventilation for more than 24 h died from pulmonary insufficiency (overall mortality = 1:71,829 anesthetics).**

Conclusions: **This study suggests that patients with clinically apparent aspiration who do not develop symptoms within 2 h are unlikely to have respiratory sequelae. (Key words: Complications: pulmonary aspiration.)**

AS a result of extensive research and clinical trials over the past decades, a number of specific anesthetic and medical conditions associated with an increased incidence of pulmonary aspiration have been identified and the potential risk for pulmonary aspiration of gastric contents has been greatly reduced.[1–9] Large epidemiologic studies from Sweden[10] and France[11] completed in the early 1980s have documented low incidences of perioperative pulmonary aspiration in adults and children. Unfortunately, most large epidemiologic studies do not rigidly define "pulmonary aspiration." The lack of a rigid definition for pulmonary aspiration may cause inaccuracies in calculating incidences, outcomes, and factors predictive for this complication.

To overcome this problem, we evaluated the perioperative courses of 172,335 consecutive patients 18 yr of age or older who underwent 215,488 elective or emergency general anesthetics at a single institution during a 6-yr period. A uniform definition of pulmonary aspiration was used. The aim of this study is twofold: (1) to update the incidence of pulmonary aspiration and (2) to determine the clinical significance of pulmonary aspiration by examining the predictive potentials of common clinical findings after perioperative pulmonary aspiration.

Methods

Study Subjects

During the 6-yr period July 1985 through June 1991, 215,488 general anesthetics were performed at the authors' institution on 172,335 patients who were 18 yr of age or older. These patients underwent 202,061 elective and 13,427 emergency surgical or diagnostic procedures that were performed in all surgical specialties.

With institutional approval, an extensive institutional integrated database consisting of 11 separate special-

* Associate Professor of Anesthesiology, Mayo Medical School.

† Assistant Professor of Anesthesiology, Mayo Medical School.

‡ Resident in Anesthesiology, Mayo Graduate School of Medicine.

Received from the Mayo Medical School and the Mayo Graduate School of Medicine, Rochester, Minnesota. Accepted for publication October 6, 1992. Supported by the Mayo Foundation and a grant from the Anesthesia Patient Safety Foundation.

Address reprint requests to Dr. Warner: Department of Anesthesiology, Mayo Clinic, 200 First Street SW, Rochester, Minnesota 55905.

ized databases was used to determine the incidence of pulmonary aspiration in the intraoperative and immediate postoperative recovery period (approximately 2 h). The primary component of the integrated database used in this study was the anesthesia database. Data for this component are recorded by anesthesia and recovery room personnel. The database was reviewed monthly for the entry "pulmonary aspiration." Based on previous experiences with this database,[12,13] this 1-month period was chosen to gain a maximum yield within a time period that provided accurate recall by personnel involved in these cases. Personnel who recorded episodes of pulmonary aspiration were individually interviewed about specifics of each occurrence. Pulmonary aspiration was defined as either the presence of bilious secretions or particulate matter in the tracheobronchial tree or, in patients who did not have their tracheobronchial airways directly examined after regurgitation, a postoperative chest roentgenogram with infiltrates not identified by preoperative roentgenogram or physical examination. Cases that did not fulfill this definition were excluded.

Secondary databases including master billing records, medical diagnoses, laboratory investigations, and radiologic interpretations were used to identify cases requiring intensive care and respiratory services in the postoperative period and that had the diagnoses of pulmonary aspiration, adult respiratory distress syndrome, pneumonia, or pneumonitis. Secondary computer-assisted identifications were correlated with the primary identification sweep.

Clinical Factors

General conditions that may be associated with increased incidence of pulmonary aspiration were considered in each identified case. These included age, gender, and presence of comorbid disease (insulin-dependent diabetes, cerebrovascular disease, peripheral vascular disease, cardiorespiratory diseases, hepatobiliary or renal dysfunction) in the preoperative period. The absence or presence of comorbid disease and its severity were rated using the physical status classification of the American Society of Anesthesiologists. Specific conditions that may predispose to pulmonary aspiration also were determined. These included pregnancy, recent oral intake, concurrent opioid administration, gastrointestinal obstruction or dysfunction including hiatal hernia, obesity, depressed level of consciousness, physical injury, previous esophageal surgery, head injury or neurologic damage, and lack of coordination of swallowing and respiration.[1] The experience and type of anesthesia provider was ascertained. When available, the volume and pH of aspirated material was recorded. After pulmonary aspiration, a history of new cough or wheeze, arterial hemoglobin oxygen saturation (Sp_{O_2}) while breathing room air and measured by pulse oximetry $\geq 10\%$ less than the preoperative value, an alveolar-arterial oxygen tension ≥ 300 mmHg in patients in whom the trachea remained intubated, and radiographic abnormalities within 2 h of aspiration or the completion of the anesthetic were elicited from anesthesia and recovery nursing personnel and radiologic records.

Data collected after the initial 2-h recovery period included disposition, use of intensive care services, ventilatory support, and pulmonary outcomes. These data were collected by individual medical record review. The Mayo Clinic employs a unit medical record system, and the complete history of every patient, including outpatient as well as inpatient data, is available for review.[14]

Validity Checks

To ascertain the validity of computer-assisted identification of pulmonary aspiration, the records of all adult patients undergoing general anesthesia during four randomly selected 2-week periods (4,396 records) were reviewed by a single clerk verifier who was unaware of any intraoperative or recovery period episodes of pulmonary aspiration. At the end of the four reviews, these data were collated with database entries for pulmonary aspiration and results of interviews with anesthesia personnel. The standard for comparison was established as a notation on the anesthesia record of vomiting and (presumed) pulmonary aspiration. In the seven cases noted in the record and found by the verifier, an entry had been made into the database. During these four 2-week periods, the database monthly scans triggered interviews in the same seven cases. Of the seven cases, interviews suggested that pulmonary aspiration meeting our strict interpretation was actually observed in only three. In the remaining four cases, the patients had vomited and bilious fluid was suctioned from the oropharynx, but no fluid or particulate matter was observed in the tracheobronchial tree. None of these four patients developed any signs suggestive of pulmonary aspiration.

During these reviews, the integrated databases identified four additional patients with pulmonary aspiration in the perioperative period by crossmatching patient identifications with notations of intensive care admissions, prolonged mechanical ventilation, and medical diagnoses. One of these patients aspirated gastric contents into the pulmonary tree after a central nervous system event on postoperative day 2, another aspirated after becoming obtunded from parenteral narcotics on postoperative day 1, and two aspirated during cardiopulmonary resuscitation after cardiac arrests on postoperative days 2 and 5.

Analysis

Comparisons of observed pulmonary aspiration in elective and emergency cases were performed by Fisher's exact test. Confidence intervals of 95% were calculated for incidences of pulmonary aspiration overall and for the elective and emergency groups. Individual risk factors in patients in whom tracheal aspiration of gastric contents occurred were compared univariately using chi-square or Fisher's exact tests and multivariately using a logistic regression model. $P < .05$ was considered significant.

Results

There were 172,335 adult patients who underwent 215,488 general anesthetics. Of these, 93,061 (54.0%) were female. Nearly 40% (68,245) of these patients were 65 yr of age or older, and 10,684 (6.2%) were 80 yr of age or older. Anesthesia for elective procedures comprised 93.8% (202,061) of all cases. There were 13,427 emergency cases.

Risk of Pulmonary Aspiration

Increasing physical status and emergency surgery were each associated with greater risk of aspiration (table 1). The risk ranged from a low of 1:9,229 anesthetics in ASA physical status I patients undergoing elective procedures to a high of 1:343 anesthetics in ASA physical status IV and V patients undergoing emergency procedures. Age, gender, pregnancy, ingestion of a meal within 3 h, concurrent administration of opioids, obesity with a body mass index ≥35, individual comorbid diseases, experience and type of anesthesia provider, and types of surgical procedure were not independent risk factors for pulmonary aspiration.

One or more specific preoperative conditions that predispose to pulmonary aspiration were present in 24 of the 52 cases of pulmonary aspiration that occurred in patients undergoing elective procedures. In the remaining 28 patients undergoing elective procedures, no predisposing conditions could be identified. All 15 of the patients undergoing emergency procedures had predisposing conditions. The most common predisposing condition in all patients was gastrointestinal obstruction, present in 21 patients. Other specific conditions included lack of coordination of swallowing (6), depressed level of consciousness (6), previous esophageal surgery (3), and recent meal (3). No pulmonary aspiration was observed in patients undergoing 256 elective and 389 emergency cesarean sections with general anesthesia. Of the 29 elective and emergency patients who aspirated and had specific conditions that predispose to pulmonary aspiration, 18 received one or more of preoperative oral antacids (12), oral or parenteral H_2 receptor antagonists (8), or medications that improve gastric emptying (4).

Table 1. Risk of Pulmonary Aspiration in Elective and Emergency General Anesthetics by ASA Physical Status Classification

ASA Physical Status	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.

Pulmonary aspiration occurred at various times in the perioperative period (table 2). In three instances, the patient vomited immediately before induction of anesthesia but the cases were continued because of the emergency nature of the surgical process. Overall, there were no predisposing conditions present in 57% of the patients in whom aspiration occurred. The majority of aspirations occurred during tracheal extubation (35.9%) and laryngoscopy (32.9%).

Outcomes of Pulmonary Aspiration

Pulmonary aspiration occurred in 67 patients (1:3,216 anesthetics). One patient died intraoperatively after aspirating bilious fluid and particulate matter prior to induction of anesthesia. The primary cause of this patient's demise was exsanguination during emergency repair of a ruptured abdominal aortic aneurysm. Of the 66 patients who survived their procedure, particulate

Table 2. Time of Pulmonary Aspiration during the Perioperative Period and Associated Conditions*

Time	n	Associated Condition
Before induction of anesthesia	3	Esophageal bleeding from varicosities (1) Ruptured abdominal aortic aneurysm (1) Ischemic bowel from superior mesenteric artery thrombosis (1)
During induction but before preplanned laryngoscopy and tracheal intubation†	4	Predisposing conditions (3) No predisposing conditions (1)
During ventilation *via* mask (no preplanned tracheal intubation)	7	No predisposing conditions (7)
During laryngoscopy†	22	Predisposing condition; inadequate muscle relaxation; patient gagged and vomited (9) No predisposing condition; inadequate muscle relaxation; patient gagged and vomited (5) Predisposing condition; difficult laryngoscopy (2) No predisposing condition; difficult laryngoscopy (6)
During tracheal extubation	24	Predisposing condition; patient gagged and vomited (6) No predisposing condition; patient gagged and vomited (18)
After tracheal extubation (>5 min)	7	Predisposing condition; patient either weak or not alert and responsive (6) No predisposing condition; patient either not weak or alert and responsive (1)

* See text for specific conditions that may be associated with pulmonary aspiration.

† Cricoid pressure was applied in all cases with predisposing conditions for pulmonary aspiration during induction and laryngoscopy.

matter was present in the aspirate of eight. These eight patients underwent immediate fiberoptic bronchoscopy. This maneuver was effective in finding and removing additional particulate matter in only three cases. Despite directed questions to participating anesthesia personnel, an estimate of the volume of aspirate was not given in 53 cases. In the remaining thirteen cases, the volume estimates ranged from 1 to 10 ml. Measurements of pH were made in only six patients, and all values were reportedly >2.5.

Forty-two patients in whom pulmonary aspiration occurred did not develop signs or symptoms associated with pulmonary aspiration within 2 h of the aspiration or completion of the anesthetic (fig. 1). None of these 42 patients required intensive care or respiratory support or developed pulmonary complications. Eighteen of these patients were originally scheduled to have their procedures performed on an outpatient basis; 12 were discharged from the hospital on the day of their procedures.

Twenty-four patients developed one or more of a new cough or wheeze (17), a decrease in Sp_{O_2} while breathing room air ≥10% less than the preoperative value (10), alveolar-arterial oxygen tension ≥300 mmHg (1), or radiologic evidence of pulmonary aspiration (12) within 2 h of aspiration or completion of the anesthetic (fig. 1). Although ten of these patients were originally scheduled to have their procedures performed on an outpatient basis, none were discharged on the day of their procedures. Eighteen of the 24 symptomatic patients required intensive care or respiratory support or developed pulmonary complications (overall morbidity risk of 1:11,971 anesthetics). Of these, 13 required postoperative mechanical ventilatory support for >6 h, seven for <24 h, and 6 for ≥24 h (table 3). A pneumonia with an identifiable etiology developed in only one patient. That patient developed Klebsiella pneumonia requiring mechanical ventilation of the lungs for <24 h. She recovered uneventfully after antibiotic therapy. None of the patients received steroids or antibiotics for nonspecific prophylaxis after aspiration. Adult respiratory distress syndrome developed in all six of the patients whose lungs required mechanical ventilation ≥24 h. Three of these patients, two of whom underwent emergency procedures, died of respiratory failure after receiving ventilatory support for 6, 8, and 52 days. The overall mortality rate from pulmonary aspiration in this population was 1:71,829 anesthetics.

Discussion

Clinically important pulmonary aspiration of gastric contents in the immediate perioperative period is uncommon. In 119,351 elective procedures and general anesthetics performed on ASA physical I and II patients, approximately only one in 8,000 exhibited any evidence of pulmonary aspiration. None of these aspirations resulted in serious pulmonary complications. Even in patients with comorbid diseases and health fac-

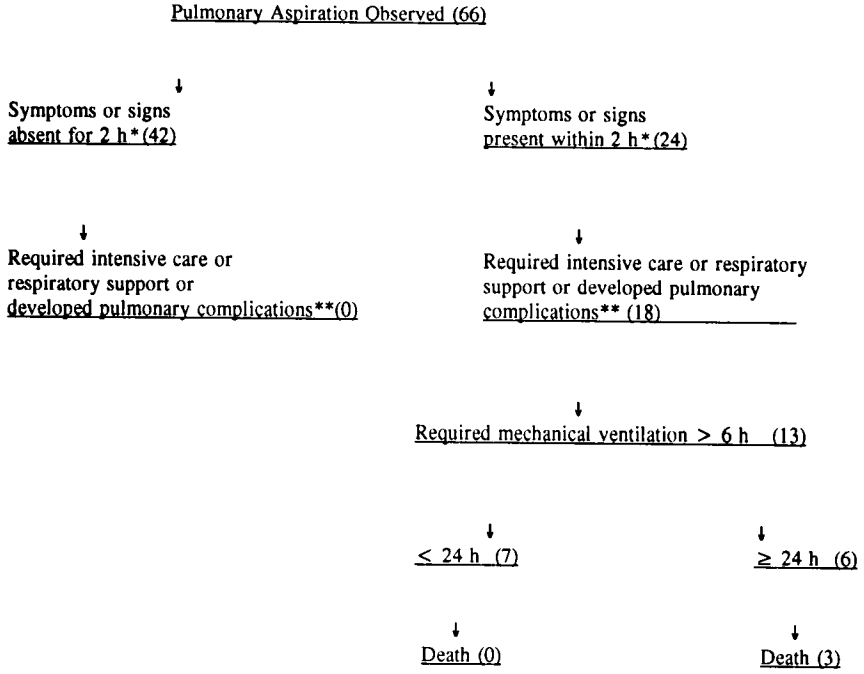

Fig. 1. Relationship of symptoms or signs of pulmonary aspiration that develop within 2 h of aspiration to pulmonary outcomes in 66 patients. * = symptoms or signs of pulmonary aspiration include development of a new cough or wheeze, a decrease in Sp_{O_2} while breathing room air ≥10% less than the 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).

tors often associated with an increased risk of pulmonary aspiration, aspiration occurred infrequently, and morbidity and mortality were low (tables 1 and 3). Only three of 66 patients with documented pulmonary aspiration died from pulmonary complications.

The most clinically applicable finding of our study is that no pulmonary sequelae developed in any of our 42 patients with a documented pulmonary aspiration and who remained asymptomatic for cough or wheeze or did not have hypoxia while breathing room air or radiographic abnormalities within 2 h of aspiration or completion of the procedure. In contrast, 75% of our patients with any of these symptoms within 2 h required supplemental oxygen to maintain an Sp_{O_2} ≥90%, ventilatory support, or both. Based on these findings, we send ambulatory patients home and inpatients to a regular nursing ward if they remain asymptomatic after 2 h of observation. Less clear is our disposition of symptomatic patients. In general, those who do not require ventilatory support within 2 h of aspiration may be sent to a regular nursing ward and closely observed if they have maintained an Sp_{O_2} ≥90% on room air or with supplemental oxygen for 2 h after aspiration. All others are admitted for observation in an intensive care area.

Table 3. Risk of Aspiration-associated Pulmonary Complications and Death after General Anesthesia by ASA Physical Status Classification

ASA 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.

Extensive research effort and finances have been consumed in identifying factors associated with risk of pulmonary aspiration and pharmacologic interventions to decrease this risk.[1] With this information and changes in patient health and anesthetic practices, has the severity of morbidity after pulmonary aspiration improved over time? Because definitions used for "pulmonary aspiration" and other variables may differ, comparisons between epidemiologic studies can be difficult or misleading. To decrease the chance of differences, we compare the results of this study with the most recent large-scale survey of adults with intraoperative pulmonary aspiration.[10] This comparison suggests that the risk of death and morbidity from this

complication has decreased by 50% in the past two decades. In their retrospective study of adult surgical patients at the Karolinska Hospital during the years 1967–70 and 1975–83, Olsson *et al.*[10] found the incidence of death after aspiration to be 1:35,000. In comparison, our mortality incidence is 1:71,829. Similarly, the incidences of morbidity serious enough to require intensive care services are 1:4,693 and 1:11,972, respectively. Clearly, the validity of a comparison between a decade-old retrospective analysis and our analysis can be questioned. Our periodic retrospective review of prospectively gathered data allowed us to more rigidly define pulmonary aspiration, a factor that alone may have accounted for differences in severity of outcomes. Similar problems of comparison, plus those of mixed patient populations, exist with other large-scale epidemiologic studies of complications during anesthesia.[10,11,15–21] Nevertheless, the 50% decrease in risk of developing major pulmonary complications or dying from aspiration appears to be a significant improvement over time.

Few of the patients undergoing general anesthesia at this institution receive medications for prophylaxis of gastric regurgitation and pulmonary aspiration. The routine use of antacids, H_2 receptor antagonists, or medications that improve gastric emptying was limited to obstetric anesthesia during the period of this study. Indeed, only 48% of the 35 elective and emergency patients in whom aspiration occurred and who had conditions that are generally acknowledged to be associated with aspiration received any of these prophylactic medications prior to induction of anesthesia. In these patients, pulmonary complications developed in approximately equal percentages between those who received and did not receive acid aspiration prophylaxis. Should these medications have been used routinely? Many studies of the use of medications to reduce gastric volume and acidity have not concluded that they be routinely administered.[7,22–25] Our data do not contribute to the resolution of this controversial issue. They suggest, however, that the incidence of aspiration and serious morbidity are sufficiently low that the cost of preventing one serious complication of pulmonary aspiration by the routine use of prophylactic medications would be very high.

The validity of this study depends on the patient population and accuracy of database identification of pulmonary aspiration. Previous studies have identified extremes of age and male gender to be associated with a higher risk of aspiration and morbidity.[10,11] This study was limited to adult patients, and advanced age and gender were not associated with these problems. Because underreporting is possible in any epidemiologic study, we performed four 2-week random and blinded checks of anesthesia records to identify events not entered into the database. Multiple databases with information related to outcomes of all patients who had a general anesthetic were queried. Based on these checks, we believe that underreporting of the incidence of aspiration was possible but not probable and that underreporting of serious morbidity associated with aspiration was unlikely. Other potential weaknesses in this study include the lack of data specific to each aspiration event. For example, the volume or pH of aspirated material was rarely quantified. These two factors are commonly used to predict outcomes of pulmonary aspiration. In our study population, these data were not consistently obtainable.

In summary, this study found no serious morbidity from pulmonary aspiration in the immediate perioperative period in nearly 120,000 elective procedures and general anesthetics in ASA physical status I and II patients. The incidence of pulmonary aspiration and severity of pulmonary outcomes are associated with the presence of comorbid diseases (ASA physical status III and higher) and procedures performed emergently. We conclude that patients with clinically apparent aspiration who do not develop symptoms within 2 h of aspiration or completion of the procedure are unlikely to have respiratory sequelae.

References

1. Coté CJ: NPO after midnight for children—a reappraisal. ANESTHESIOLOGY 72:589–592, 1990

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

3. Coté CJ, Goudsouzian NG, Liu LMP, Dedrick DF, Szyfelbein SK: Assessment of risk factors related to the acid aspiration syndrome in pediatric patients—gastric *p*H and residual volume. ANESTHESIOLOGY 56:70–72, 1982

4. Roberts RB, Shirley MA: Reducing the risk of acid aspiration during cesarean section. Anesth Analg 53:859–868, 1974

5. Blitt CD, Gutman HL, Cohen DD, Weisman H, Dillon JB: "Silent" regurgitation and aspiration during general anesthesia. Anesth Analg 49:707–713, 1970

6. Petring OU, Adelhoj B, Jensen BN, Pedersen NO, Lomholdt N: Prevention of silent aspiration due to leaks around cuffs of endotracheal tubes. Anesth Analg 65:777–780, 1986

7. Moir DD: Cimetidine, antacids, and pulmonary aspiration. ANESTHESIOLOGY 59:81–83, 1983

8. Cameron JL, Mitchell WH, Zuidema GD: Aspiration pneumonia. Arch Surg 106:49–52, 1973

9. Dines DE, Titus JL, Sessler AD: Aspiration pneumonitis. Mayo Clin Proc 45:347–360, 1970

10. 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

11. Tiret L, Nivoche Y, Hatton F, Desmonts JM, Vourc'h G: Complications related to anaesthesia in infants and children. Br J Anaesth 61:263–269, 1988

12. Warner MA, Hosking MP, Lobdell CM, Offord KP, Melton LJ: Surgical procedures among those ≥ 90 years of age: A population-based study in Olmsted County, Minnesota, 1975–1985. Ann Surg 207:380–386, 1988

13. Hosking MP, Warner MA, Lobdell CM, Offord KP, Melton LJ: Outcomes of surgery in patients 90 years of age and older. JAMA 261: 1909–1915, 1989

14. Kurland LT, Molgaard CA: The patient record in epidemiology. Sci Am 245:54–63, 1981

15. Hunter AR, Moir DD: Editorial: Confidential enquiry into maternal deaths. Br J Anaesth 55:367–369, 1983

16. Lunn JN, Hunter AR, Scott DB: Anaesthesia-related surgical mortality. Anaesthesia 38:1090–1096, 1983

17. Green NM, Bannister WK, Cohen B, Keet JE, Mancinelli MJ, Welch ET Jr, Welch HJ: Survey of deaths associated with anesthesia in Connecticut. Conn Med 23:512–518, 1959

18. Harrison GG: Death attributable to anaesthesia: A 10-year survey. Br J Anaesth 50:1041–1046, 1978

19. Hovi-Viander M: Death associated with anaesthesia in Finland. Br J Anaesth 52:483–488, 1980

20. Crawford JS: The anaesthetist's contribution to maternal mortality. Br J Anaesth 42:70–73, 1970

21. Krantz ML, Edwards WL: The incidence of nonfatal aspiration in obstetric patients. ANESTHESIOLOGY 39:359, 1973

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

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

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

25. Tompkinson J, Turnbull A, Robson G, Cloak E, Adelstein AM, Weatherall JAC: Report on Confidential Enquiries into Maternal Deaths in England and Wales 1973–1975. London, Her Majesty's Stationery Office, 1979, pp 80–81