Medical Intelligence

The Pediatric Patient with a Full Stomach

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Aspiration of gastric contents continues to be a major hazard in anesthetized patients. It is estimated that 12 to 24 per cent of anesthetic deaths result from inhalation of stomach contents.1–4 Seventy-five per cent of all the avoidable deaths in obstetric patients have been attributed to aspiration.5 In one report on pediatric anesthesia mortality, it was found that 26 per cent of anesthetic deaths were due to aspiration of vomitus or blood.6

The pathophysiology of vomiting, regurgitation, and aspiration in adult patients have been extensively treated.7–10 Because of the physiologic differences between infants and adults, some of the methods advocated for adult patients11–17 may not be suitable for the infant. This report outlines some specific problems in the management of infants and children and reviews the various approaches that are applicable to the pediatric patient.

Physiologic Considerations

A number of factors combine to make the infant more vulnerable to regurgitation and aspiration. The resting intragastric pressure may be higher in anesthetized infants than it is in adults. This is due to the relatively small size of the stomach, encroachment of some abdominal organs, excessive air swallowing during crying, and strenuous diaphragmatic breathing.18 In newborns a mild form of relaxation of the gastroesophageal vestibule may exist.19 Once gastric contents are forced up into the esophagus, they may readily find their way into the pharynx because of the short esophagus of the infant.

Incoordination of the breathing and swallowing mechanisms may occur in premature and dyspneic infants.19 In addition, they may not have well-developed cough reflex.20 Laryngeal malfunction, laryngeal spasm, and vocal cord paralysis have been emphasized as important contributing factors to pulmonary aspiration in the newborn infant.21, 22

Although milk fed to normal infants is virtually completely evacuated from the stomach by the end of four hours, gastric emptying depends on many factors. In the premature and small infant, emptying is somewhat delayed. The excessive amount of mucus sometimes found in the stomachs of such infants, and the decrease in acid secretion, tend to contribute to gastric stasis.19

Except during the early weeks of life in premature infants and malnourished children, the pH values of gastric juice in infants and adults are similar.19 However, the pH of stomach contents may be altered by frequent milk feedings. A dairy diet results in stomach contents of higher pH (pH 3.8) than a carbohydrate diet (pH 1.8).23

Clinical Considerations

Certain anesthetic factors which can predispose to regurgitation may play critical roles in inducing regurgitation in the infant. Airway obstruction, being rather common in unintubated infants, enhances regurgitation by increasing the pleuropertoneal pressure differences during spontaneous breathing, and by raising the intragastric pressure due to overaction of the diaphragm.24 Positive-pressure ventilation (in excess of 20 cm H2O) prior to tracheal intubation may lead to intermittent opening of the criopharyngeus and cardia, with subsequent rise in intragastric pressure.18 Excessive anterior angulation of the infant's larynx during laryngoscopy may stretch the criopharyngeus and thus facilitate regurgitation.25

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Received from Cook County Hospital, Chicago, Illinois 60612. Accepted for publication January 2, 1973.
The immediate danger of aspiration is that of mechanical obstruction of the respiratory passages. Because of the narrow airway in the infant, this could be rapidly fatal. Although adequate ventilation is usually re-established, the patient may subsequently develop severe pulmonary complications, including pulmonary aspiration (Mendelson's) syndrome, atelectasis, and aspiration pneumonia. A pH below 2.4 appears necessary for pulmonary damage to develop if gastric juice is aspirated. However, pH may not be the only determining factor if food particles are also aspirated. While there is little difference between pulmonary responses to filtered and unfiltered gastric contents following a carbohydrate diet (pH 1.8), unfiltered gastric aspirate after a dairy diet (pH 3.8) produces more severe and prolonged changes in the lungs, compared with filtered contents.

Milk (pH 6.7) and sugar in water (pH 4.5) have similar irritant effects on the rabbit's lung, but distilled water (pH 4.0) is less irritating. The effect of milk is related to the presence of residual material in the alveoli following aspiration. Feeding mixtures cause a greater degree of pulmonary edema than human or cow's milk when aspirated, due to their high carbohydrate content and consequent hypertonicity. Aspiration of ingested food such as meat and vegetables or fecally contaminated gastric contents produces a severe reaction regardless of the pH.

Preventive Measures in Awake Infants

Regurgitation following feeding is considered a natural occurrence during the first six months of life. However, it can be reduced to a negligible amount by feeding the infant in a semi-sitting position for facilitation of eructation, gentle patting of the back in the upright position after feeding to expel swallowed air, and placing the infant on the right side or abdomen after feeding to prevent aspiration, and facilitate emptying of the stomach.

Because aspiration may occur during the choking that accompanies initial feedings in newborns, water would be a safer test substance than 5 per cent glucose or milk. Similar considerations might be extended to the first oral feedings of patients recovering from anesthesia, trauma to the nervous system, or comatose states.

Patients with Pierre-Robin syndrome are better nursed in the prone position or on their sides in order to maintain a patent airway. Frequent suction of salivary secretions preoperatively is of utmost importance in patients with tracheosophageal fistulas to reduce the danger of aspiration. Rees recommends use of the head-down prone position to assist drainage of secretions in these patients preoperatively and postoperatively.

Preanesthetic Procedures

EMPTYING THE STOMACH AND ESOPHAGUS

Delaying the operative procedure, if this is feasible, or removal of gastric contents by a wide-bore stomach tube help to reduce the intragastric pressure before induction of anesthesia. In cases of intestinal obstruction, the introduction of a stomach tube to reduce the intragastric pressure until induction of anesthesia is necessary. On the other hand, attempts to empty the stomach may be followed by aspiration in premature and poor-risk patients.

The esophagus may contain a large amount of fluid in certain situations such as intestinal obstruction, esophageal diverticulum, and incompetence of the cardia. So long as the patient is awake, this material is prevented from entering the pharynx by the intact cricopharyngeal sphincter. Once the sphincter is relaxed by neuromuscular blocking agents or deep anesthesia, the pharynx may be flooded by material. In such situations, applying suction to the esophagus prior to induction decreases the possibility of aspiration.

NEUTRALIZATION OF ACID GASTRIC CONTENTS

Taylor and Pryse-Davies introduced the regimen of prophylactic oral administration of magnesium trisilicate to elevate the pH above 2.5 preoperatively. A mixture of magnesium hydroxide, aluminum hydroxide, and simethicone (Mylanta) has been similarly recommended for use in children prior to induction of anesthesia for adenotonsillectomy. The neutralization of gastric acidity to a pH value above the critical range helps to alleviate the complications of aspiration of gastric juice, but does not protect against the damage pro-
duced by food particles. In the presence of a substantial amount of retained contents, antacid therapy may not be effective. Alkalization of gastric contents may also result in delayed emptying.

Preoperative Gastrostomy

In newborns with tracheoesophageal fistulas, intermittent positive-pressure ventilation may lead to gastric inflation, resulting in regurgitation and cardiovascular and respiratory embarrassment. Besides serving as a vent and reducing the risk of regurgitation, a functioning gastrostomy will help prepare critically ill babies, permit early postoperative feeding, and put the esophagus at rest during healing of the anastomosis.33

Use of Belladonna Alkaloids

Intravenous administration of atropine may exert a beneficial effect by increasing the resistance to reflux, as has been shown by Clark and Riddoch.24

Anesthetic Procedures

Certain emergency operations in newborns, and cooperative older children, may be successfully performed using regional anesthesia. Except for this technique and dissociative anesthesia with ketamine, all other techniques aim at protecting the airway by means of a tracheal tube.

Dissociative Anesthesia without Intubation

It has been claimed that during ketamine anesthesia, laryngeal reflexes remain intact, patency of the airway is ensured, and aspiration is prevented.35,36 Recently, a number of complications have been documented and indicate that the use of ketamine without intubation may be hazardous in children with full stomachs. Respiratory obstruction, apnea, increased salivation, laryngospasm, and vomiting with subsequent aspiration have all been reported.37,38 Taylor and Towey have recently assessed the competence of the laryngeal closure reflex under ketamine anesthesia and found clear-cut evidence of aspiration of opaque material into the lungs.29

Intubation in the Conscious State without Relaxants

In certain situations, intubation while the patient is awake is the method of choice. These include: neonates in their first week of life; congenital diaphragmatic hernia; tracheoesophageal fistula; near-moribund patients; severe intestinal obstruction; gastric bleeding; patients with anatomic abnormalities that may render intubation difficult, such as bilateral cleft palate, Pierre-Robin syndrome, and facial injuries. Placing the tip of the tracheal tube below the fistulous opening in patients with tracheoesophageal fistulas will prevent gastric inflation and aspiration.40 Topical anesthesia to the larynx is better avoided in the infant. The newborn’s larynx is relatively insensitive compared with the adult larynx.50 If topical anesthesia is used, the larynx must be continuously visualized until intubation is accomplished, to avoid silent regurgitation. Intravenous injection of diazepam may facilitate the procedure in older children.

Intravenous Induction of Anesthesia Combined with Relaxants

In this method, induction is achieved with thiopental sodium (3–4 mg/kg), immediately followed by a full paralyzing dose of succinylcholine (2 mg/kg), and a tracheal tube is inserted once paralysis is complete.15 Since the lungs must not be manually ventilated until the tube is in place, preoxygenation, by delivering a high flow of oxygen above the patient’s face, should precede induction. Vomiting appears to be rare. Rees found that vomiting occurred in seven of 532 pediatric patients subjected to emergency procedures when this technique was used.41 Inhalation induction using halothane or cyclopropane as an alternative to thiopental sodium, followed by the administration of a relaxant, may be used, especially if barbiturates are contraindicated or access to a vein cannot be established before induction.

Because of the lack of rise in intragastric pressure following intravenous injection of succinylcholine in infants, and because of the antagonistic actions of the depolarizing and antidepolarizing types of blocks, prior administration of d-tubocurarine or similar drugs may
Fig. 1. Distance of the larynx above the cardia with 40-degree head-up tilts in infants, children and adults. Based on a larynx-cardia distance of about 27 cm in the adult and a 10-degree inclination of this line to the vertical axis of the body, a 40-degree head-up tilt raises the adult's larynx 19 cm above the gastroesophageal junction. Corresponding figures at different ages were calculated. Placing infants and children in 40-degree head-up tilts fails to raise the larynx sufficiently to overcome increased intragastric pressure.

Fig. 2. Distance of the larynx above the cardia in sitting-up position in infants, children and adults. Placing infants and children in the sitting-up position does not provide adequate hydrostatic pressure to counteract increased intragastric pressure. Because of the short esophagus in the newborn, the larynx can be raised only 11 cm above the gastroesophageal junction, compared with 26 cm in the adult. Even in a 10-year-old child, head-up tilt may not prevent stomach contents from reaching the laryngeal level.

not be advisable. Partial paralysis may not prevent active vomiting or coughing. This can, of course, be avoided by injecting an adequate dose of succinylcholine. With complete relaxation of the abdominal muscles and diaphragm, vomiting is unlikely, but regurgitation is possible. Efforts to enhance the safety of this technique have been directed to preventing material from reaching the upper esophagus. This has been accomplished by head-up tilt, cricoid pressure, or combination of the two.

Head-up Tilt. The basis of this method stems from O'Mullane's observation that the maximum expected intragastric pressure in adult patients is 18 cm H₂O. Placing the average adult patient in a 40-degree head-up tilt will raise the larynx 19 cm above the gastroesophageal junction. It is assumed that gastric contents will not reach the laryngeal level even if forced up into the esophagus in this position. Because of the short esophagus in the infant, it is impossible to obtain a hydrostatic pressure sufficient to counteract the increased intragastric pressure, even if the infant is placed in the upright position (figs. 1 and 2). Intragastric pressures higher than 18 cm H₂O have been observed in infants and children. For these reasons, head-up tilt is of little value in preventing material from
reaching the laryngeal level in pediatric patients.

**Cricoid Pressure.** "Sellick's maneuver"; This method has been shown to be equally effective in adult 12, 13 and pediatric 42 patients. By obliterating the esophageal lumen, it prevents regurgitated material from reaching the pharynx. 12, 13, 42 Prior to induction an assistant palpates the cricoid ring lightly between the thumb and the middle finger; then the pressure is steadily increased after loss of consciousness, using the index finger, while the neck is kept extended. The maneuver is also effective in sealing the esophagus in the presence of a nasogastric tube despite an intraesophageal pressure of 100 cm H2O. A nasogastric tube need not be withdrawn before induction of anesthesia, since it can act as a "blow-off" valve if an increase in intragastric pressure occurs, while cricoid pressure will prevent regurgitation of gastric contents into the pharynx.42

In certain situations, cricoid pressure may not be desirable. In the presence of an upper esophageal pouch or diverticulum, it may actually facilitate aspiration. Cricoid pressure is better avoided in the presence of a retropharyngeal abscess because of the inherent danger of rupturing the abscess and flooding the tracheobronchial tree. Esophageal rupture, a theoretical possibility in case active vomiting occurs during cricoid compression, has not been reported.

**Inhalation Induction and Induced Hyperventilation**

In this technique, laryngeal reflexes are preserved during induction using diethyl ether, cyclopropane, or halothane. Hyperventilation is induced early by the temporary administration of 5 to 15 per cent carbon dioxide to overcome breath-holding, an essential preliminary to active vomiting. When a deep plane of anesthesia is obtained, intubation is carried out in an unhurried manner without the use of relaxants while spontaneous respiration is maintained.14

The inhalation technique is usually performed with the patient in the supine position, with a head-down tilt so that gastric contents can find their way into the oropharynx rather than flow against gravity into the larynx in case regurgitation occurs.14 In this position, laryngoscopy may be cumbersome, the intragastric pressure may be increased, and greater respiratory effort may be required.14 Unless a clear airway is maintained, regurgitation is possible. This makes the technique unfavorable for the small infant, in whom upper respiratory obstruction may occur.

**Extubation**

The tracheas of infants and children with the risk of vomiting and regurgitation should be extubated only after the patients are fully awake and have regained adequate laryngeal reflexes. The infant is more prone to develop respiratory obstruction if extubation is done prematurely. It is preferable to remove the tube with the patient in a 10-degree head-down position while maintaining 15–20-cm H2O positive airway pressure. This induces reflex coughing upon removal of the tube and helps prevent inhalation of material present in the pharynx and larynx.

**References**


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