Part II: Respiratory Failure

Chapter 30: Aspiration Syndromes

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Aspiration of fluid, with or without solids into the lower respiratory tract is a common and potentially serious problem. There is a high associated mortality rate (about 60%), depending on the volume and type of aspirate, although it is usually preventable.

Aetiology

Aspiration results from the simultaneous occurrence of two abnormalities:

1. presence of fluid (i.e. gastric contents or blood) or particulate matter in the pharynx; and
2. impaired laryngeal defence, allowing pharyngeal contents to enter the lung.

Table 1. Conditions with Aspiration Risks

Altered Conscious States
Cerebrovascular accidents
Head injuriesw
Epilepsy
General anaesthesia
Alcohol or drug overdose
Metabolic coma
Impaired cough and gag reflexes
Recent extubation of larynx
Motor or sensory bulbar disturbance
Elderly patients
Seriously ill patients
Passive regurgitation
Obstetric cases
Emergency surgery for bowel obstruction
Hiatus hernia
Oesophageal obstruction
Nasogastric tube
Raised intra-abdominal pressure by succinylcholine
Oesophagoscopy

Table 1 shows some conditions which predispose to aspiration of gastric contents. It is important to be aware of the risk of passive regurgitation, when there is either a depressed

conscious state or impaired cough and gag reflexes. Wide bore nasogastric tubes prevent closure of the upper and lower oesophageal sphincter, and also interfere with coughing and clearing of the pharynx. They may thus predispose to aspiration. Endotracheal intubation is protective against large volume aspiration, but, by splinting the vocal cords and epiglottis open, allows small volumes of pharyngeal fluid to pass below the vocal cords and accumulate above the endotracheal tube cuff. Indirect evidence from bacterial isolation patterns and glucose testing of endotracheal aspirate, suggests that small amounts of this fluid enter the lung. Such micro-aspiration does not cause major lung injury, but is associated with microbial colonization of the lung which may be harmful.

Types of Aspiration

The most useful classification of the aspiration syndromes is based on the nature of the aspirate:

1. acid aspiration;

2. infected fluid aspiration;

3. inert fluid aspiration;

4. particulate aspiration; and

5. other substances.

Acid Aspiration

The most serious form of aspiration is that resulting from acidic gastric contents. Consequent severity of lung injury is dependent on the volume and pH of the aspirate. There is a reported 100% mortality in patients whose gastric pH was less than 1.8 at the time of aspiration, and 25% mortality in those with a pH between 1.8 and 2.5. Although aspiration of gastric contents with a pH above 2.5 is considered to be non-acid aspiration, it is now recognized that this can also produce a similar, though less severe, pulmonary injury that is pathologically distinct from aspiration of non-gastric neutral fluids.

Normal gastric contents are acidic and free of microbial contamination. Consequently, with aspiration occurring in a previously well non-hospitalized patient, the aspiration fluid itself will not infect the lungs. Although the process of aspiration may introduce oral flora into the lower respiratory tract with the gastric contents, initial cultures are often negative. Subsequent colonization of the lower respiratory tract by predominantly gastrointestinal (GIT) gram negative organisms commonly occurs. This pattern appears to conform to that of any critically ill patient without being specific to acid aspiration. The pathological role of this colonization is uncertain but may be significant.

Pathology: Damage occurs within minutes of acid aspiration. There is loss of alveolar-capillary integrity and exudation of fluid and protein into the alveoli and bronchi. Within a few hours, there is bronchial epithelial degeneration, destruction of type II alveolar cells, and a polymorphonuclear cell infiltration, which progresses to alveolar consolidation.

Macroscopically, the lungs are heavy, oedematous and haemorrhagic. At 48 hours, hyaline membranes can be seen, and at 72 hours, there is a reduction in the acute inflammatory response, with proliferation of fibroblasts and regeneration of bronchial epithelium.

Clinical features: Mendelson's syndrome is the term used to describe the severe dyspnoea, cyanosis, asthma-like reaction, and shock in association with the chemical pneumonitis from aspiration of a large volume of gastric fluid with pH less than 2.5. Interestingly, the patients originally described by Mendelson did not conform to acid aspiration in illness severity or mortality, and were more probably non-acid aspiration. Hypoxia can occur within minutes and is accompanied by dyspnoea and wheeze. Exudation of protein-rich fluid into the alveoli leads to pulmonary oedema and a fall in dynamic compliance. This is often accompanied by hypovolaemia and hypotension. Chest X-ray usually shows diffuse bilateral pulmonary infiltrates, more marked at the lung bases, and may be indistinguishable from adult respiratory distress syndrome (ARDS). The clinical course of patients with severe aspiration is characterized by severe pulmonary injury and complications including circulatory failure, multisystem organ failure, and sepsis. Mortality is high, 25-100% depending on the severity of the insult and the host status.

Infected Fluid Aspiration

Although normal gastric acid contents are organism free, this is not so during illness and with use of antacid medication. All critically ill patients will have bacteria isolated from their nasogastric aspirate within 4 days of commencing antacid therapy, and 30% will have candidiasis. Organisms isolated are dominated by gram negative bacteria and anaerobes normally found in the lower GIT. Similar patterns of colonization of gastric fluid have also been found in a variety of GIT disturbances, achlorhydria, and paralytic ileus from any cause.

In 50-80% of critically ill patients, spread of GIT organisms to the lower respiratory tract by micro-aspiration of gastric contents can be demonstrated. Factors facilitating the retrograde spread of gastric fluid in the critically ill patient are the abscence of normal peristaltic and sphincteric action (due to sedation, paralytic ileus, and the nasogastric tube), the recumbent posture, and the presence of an endotracheal tube. In addition, the oropharynx may become heavily colonized during illness or in patients with poor oral hygiene. Such oropharyngeal flora will commonly also colonize the stomach and be introduced into the lungs directly by micro-aspiration.

The pathogenic role of gastric bacteria has now been clearly shown. Studies using prophylactic antibiotics to reduce bacterial and fungal colonization have resulted in a reduced incidence of pneumonia, septicaemia and death. Macroscopic aspiration is less common, but when it occur in a previously ill or hospitalized patient, especially those with GIT dysfunction or antacid treatment, a heavy innoculum of pathogenic bacteria will occur into the lower respiratory tract. This may be followed by infection and necrotizing bacterial pneumonia may occur. The organisms found depend on the clinical background of the host. In non-hospitalized patients, anaerobic oral flora sensitive to penicillin dominate. However, in hospitalized patients, cultures are dominated by GIT gram negative aerobes and anaerobes, which require a more broad spectrum antibiotic cover (Table 2).

Table 2. Lung Colonization Patterns Following Aspiration

Previously well, Non-hospitalized

Predominant oral flora, anaerobes/aerobes = 10/1
Bacteroides melanogenicus
Fusobacterium nucleatum
Peptostreptococcus
Bacteroides fragilis, oralis
Microaerophilic streptococci
Pneumococcus

Previously unwell, Hospitalized, Antacid used

Predominant GIT organisms and opportunists
E. coli, Klebsiella
Pseudomonas Proteus
Other Enteric flora
Staph. aureus
Candida albicans
Anaerobes

The histological changes are similar to, although less severe than, those seen in acid aspiration, but alveolar cell necrosis and the initial polymorphonuclear infiltration are less marked. Subsequent pathology becomes that of lower respiratory tract infection and pneumonia. The clinical course of infected, non-acid aspiration depends on the volume of aspirate, the efficacy of antibiotics, and whether lower respiratory infection becomes established. Although, with major aspiration, the initial hypoxaemia may be as severe as that of acid aspiration, initial alveolar injury is not as great, and hypotension and a prolonged ARDS-like injury are less common. The lung injury may progress to gradual resolution; otherwise, a more severe, prolonged illness ensues if pneumonia develops.

Inert Fluid Aspiration

Aspiration of neutral fluids which are free of bacteria and particulate matter such as blood, activated charcoal, isotonic solutions, and fresh or salt water, produces minimal or only transient chemical injury to the lung. The severity of clinical illness depends primarily on the volume of aspirate. Although lung injury may be mild, the physical presence of fluid disrupts gas exchange and can result in dyspnoea, cyanosis, and profound hypoxia. Chest X-ray shows focal or diffuse bilateral pulmonary infiltrates, indistinguishable from other forms of liquid aspiration. The clinical course is usually one of rapid improvement over several days, concurrent with radiological clearing, with little or no long term sequelae.

Particulate Aspiration

Particulate matter, such as partly masticated meat and vegetable material, may be aspirated either directly from the pharynx, or from vomited gastric contents. Aspiration of bone, tooth or amalgam fragments may follow jaw trauma, and inorganic objects (i.e. beads,

laryngoscope globes, gravel, coins, etc) can be aspirated under specific circumstances. Large inhaled particles will cause obstruction of major airways. Irritative food particles (i.e. meat, vegetable and dairy products) will, after an initial neutrophilic response, produce a more slowly developing and widespread granulomatous reaction, with macrophages and giant cells appearing at 48 hours. At 72 hours, most of the reaction is mononuclear with numerous granulomata. Hyaline membranes do not form, and despite a fibroblastic response at 3-7 days, minimal fibrosis remains at 21 days.

The clinical features of particulate aspiration depend on the volume of aspirate, the size of the particles and their complications. Large particles lodging in the hypopharynx, larynx or trachea will cause acute upper airway obstruction. Particles obstructing large airways may cause persistent coughing, dyspnoea, and focal or generalized wheezing. Uncleared particles may give rise to secondary infection, necrotizing pneumonia, abscess formation and empyema. Chest X-ray will commonly show focal consolidation or collapse corresponding with the obstructed areas, and radio-opaque particles may be visible. Non-obstructing particulate aspiration resulting from fine food particles in neutral gastric fluid (i.e. after a meal) may cause a clinical and radiological picture similar to that of acid aspiration. However, the fluid shift from the intravascular space to the lungs occurs later (about 3-4 hours after aspiration), and is not as great. Nevertheless, hypoxia may be just as severe, and the mortality rate is similar to that of acid aspiration if large volumes are aspirated.

Aspiration of Other Substances

A large variety of other substances which are injurious to the lung may occasionally be aspirated. These include feeding solutions and other lipid containing liquids, volatile hydrocarbons, and noxious gases. Each has a distinct clinical pattern and may produce unique histopathological features such as those seen in lipoid pneumonia.

Clinical Features

Although the aspiration syndromes differ in severity, course and outcome, they have many clinical features in common.

Acute aspiration is typically manifested by a sudden onset of some or all of the following: cough, dyspnoea, wheeze, tachypnoea, stridor, crepitation, rhonchi, cyanosis, hypotension, tachycardia and fever. There may be a history of vomiting, or evidence of vomitus, other secretions, or blood in the mouth or adjacent areas. However, absence of vomitus or other secretions does not exclude the diagnosis. A risk factor predisposing to aspiration (Table 1) is usually evident.

Chronic recurrent aspiration is most commonly seen in patients with subtle abnormalities of bulbar function. It may present with an insidious deterioration of respiratory function, in association with intermittent symptoms including cough, dyspnoea, wheeze, crepitations and rhonchi. There may be a history of coughing or choking after food or fluid ingestion. Careful neurological examination may be required if the risk factor for aspiration is not obvious.

Diagnosis

Diagnosis involves ascertaining that aspiration has occurred and establishing its type.

Establishing Diagnosis

1. *A clinical trial* is the basis for an initial diagnosis, namely

(a) a deterioration in respiratory function,

(b) history or evidence of vomiting, or presence of aspiratable substances, and

(c) identification of a predisposing factor (Table 1).

2. *An endotracheal aspirate sample* can confirm the diagnosis if it is similar in appearance to nasogastric aspirate, if bilirubin can be detected using a reagent strip indicator (i.e. Ames Multistix or Bililabstix), or if food or other particulate matter can be identified.

3. *Bronchoscopy* can confirm the diagnosis by identifying particulate matter. Cytological examination of *bronchial washings* should be sent to identify vegetable or meat fibres.

4. *Chest X-ray* findings are non-specific and may not be evident for a few hours. However, absence of a pulmonary infiltrate thereafter, excludes a major aspiration injury. Bilateral diffuse shadowing is present in over 50% of cases, being extensive in severe acid aspiration. If focal changes are present, the regions most commonly affected are the right upper lobe in the supine patient, and the right middle and lower lobes in the sitting or semirecumbent patient.

5. *Laryngeal incompetence* may be detected in patients who are otherwise neurologically normal, by careful observation of the patient drinking a small amount of water, or by laryngoscopy or a barium swallow.

Establishing Type of Aspiration

1. Vomitus and/or nasogastric aspirate should be

(a) examined for the presence of particulate matter,

(b) tested for pH prior to any antacid administration, and

(c) gram stained and cultured.

2. An endotracheal aspirate sample should be gram stained and cultured.

3. Bronchoscopy may be required to determine the presence or extent of particulate aspiration and to remove aspirated particles.

Establishing Severity of Aspiration

Severity of aspiration is best assessed by the clinical features and the degree of hypoxia by blood gases or pulse oximetry.

Differential Diagnosis

If evidence of aspiration is not obvious or if subtle abnormalities of bulbar function are present, aspiration may be misdiagnosed as acute pulmonary oedema, asthma, sputum retention or ARDS. As a result, aspiration may not be appropriately treated, leaving the patient at risk of further aspiration. Care must be taken to exclude aspiration when the above diagnoses are considered.

Management

1. Immediate Measures

If the incident is observed, immediate measures to clear the tracheobronchial tree are indicated. The patient should be turned onto the right side, and tilted head downwards. This may localize the aspiration to the right side of the lungs and prevent further aspiration from occurring. Suction and oxygenation can then be applied. If the patient has a reduced level of consciousness or has inadequate airway protection or clearance, the trachea should be intubated and aspirated as quickly as possible. Although inhaled fluid quickly disperses, suction will clear any solid or semisolid material. If clinical and radiological signs of airway obstruction are present, bronchoscopy should be performed.

In the conscious patient with minimal respiratory distress, it is reasonable to rely on chest physiotherapy to clear the tracheobronchial tree. However, if significant respiratory distress is present, tracheal intubation and suction is indicated. In all patients following intubation, and in some patients not requiring intubation, a nasogastric tube should be inserted to empty the stomach and reduce the risk of further aspiration. Bronchial lavage is of doubtful value, as pulmonary epithelial damage occurs early and bronchial secretion quickly buffer any aspirated material.

2. Oxygen Therapy

A high inspired oxygen fraction (FIO_2) should be supplied, to esnure a safe PaO_2. Continuous pulse oximetry should be performed or arterial blood gases should be taken at regular intervals, to monitor lung function.

3. Mechanical Ventilatory Support

The indication for controlled ventilation are respiratory distress and failure to maintain satisfactory PaO_2 or $PaCO_2$ levels. Positive end expiratory pressure (PEEP) is often required where a high FIO_2 is necessary to maintain an adequate PaO_2.

4. Bronchodilator Therapy

In acid aspiration, bronchospasm may be severe. Although the efficacy of bronchodilators in this condition is not great, inhaled beta-2 adrenergic bronchodilators should be given. Aminophyline (IV 5-6 mg/kg/h as an infusion) may be added.

5. Cardiovascular Support

In severe acid aspiration, the outpouring of protein-rich fluid into the lungs cause severe hypotension, which is best treated with plasma (i.e. 5% stable plasma protein solution). In the severely ill, Swan-Ganz catheterization with maintenance of a relatively low pulmonary capillary wedge pressure may be useful. Inotropic support may be necessary. Adrenaline (1-10 microg/min) or dopamine (5-20 microg/kg/min) are usually effective. Cautious monitoring of fluid balance is necessary, and mild fluid restriction is indicated, after the circulation has been stabilized, especially while the patient requires mechanical ventilation. Diuretic therapy is indicated if pulmonary oedema is associated with an elevated pulmonary capilly wedge.

6. Bronchoscopy

Therapeutic bronchoscopy is indicated if there is:

(a) particulate aspiration; or

(b) focal pulmonary collapse (suggesting large airway obstruction); or

(c) foreign bodies are visible on chest X-ray.

Rigid bronchoscopy allows wide bore suctioning and access of large grasping instruments into the lower respiratory tract. It is usually the procedure of choice, especially for the removal of semi-solid material. Rigid bronchoscopy does, however, carry the inconvenience of requiring general anaesthesia and re-intubation. Also, because of its size and rigid nature, it has limited access to upper lobes and more peripheral airways. Flexible fibreoptic bronchoscopy may be performed under local anaesthesia, through an existing endotracheal tube. With a wide range of grasping instruments available, it may be the procedure of first choice for more peripheral airwat occlusion, especially those beyond direct vision and for solid foreign particles (i.e. tooth or amalgam fragments).

7. Antibiotics

The role of infection in aspiration is uncertain and the use of antibiotics debated. It is useful to consider lower airway colonization or infection in 4 categories.

(a) *Aspiration of oral flora.* This usually occurs in previously well, non-hospitalized patients (Table 2) and may be associated with acid, particulate or inert aspiration. It is dominated by penicillin sensitive anaerobes. However, the pathogenic role of these bacteria is doubtful, and there have been no studies showing clear benefit from the use of penicillin. Secondary airway colonization with bowel flor may follow depending on the severity and duration of illness.

(b) *Heavy micro-organisms innoculation due to infected fluid aspiration.* This usually occurs in previously unwell, hospitalized patients, especially those on antacid therapy. Although there have been no studies specific to this group, there is indirect evidence of the pathogenic role of aspirated bacteria and the benefit of antibiotics.

(c) *Secondary airwayl colonization of a lung already injured by aspiration.* Microbiological isolation patterns are not specific to aspiration but conform with those seen in any seriously ill patient. Several studies have shown no benefit from antibiotics following aspiration and many believe infection does not play a major pathogenic role. However, there have been no well controlled clinical studies in patients with aspiration, and more recent studies of critically ill patients without aspiration suggest benefit from antibiotics in controlling such secondary infection.

(d) *Secondary infection in obstructing particulate aspiration.* Primary therapeutic requirement remains relief of the obstructed airway and drainage of any infected fluid collections. However, the pathogenic role of bacteria in necrotising pneumonia and empyema is not debated.

As the role of infection remain uncertain, the role of antibiotics remains controversial with no clear evidence of benefit or lack thereof. Although an expectant approach is recommended by some authors many others recommend their use despite uncertainty about their efficacy. If prophylactic antibiotics are to be used, a rational approach should be based on the type of aspiration which has occurred, and the bacteria commonly associated (Table 2).

More serious and prolonged lung injury is associated with acid, infected and particulate aspirate, all of which have a risk of both primary and secondary lung infection, and the use of antibiotics can be justified. This will necessitate gram positive, gram negative, and anaerobe cover, and flucloxacillin, a third generation cephalosporin, with metronidazole or clindamycin for anaerobe cover will achieve this. Third generation cephalosporins are prefered to aminoglycosides in airway infections because of their improved penetration and activity in respiratory secretions.

An expectant approach without antibiotics may be taken with inert fluid aspiration where more prompt resolution without complications can be expected. Regular sputum cultures should be performed to detect the emergence of any pathogens and antibiotics commenced only if clinically indicated.

8. Corticosteroids

Although some studies using animal models have suggested benefit from very early administration of steroids, the majority of studies in both acid and non-acid aspiration have concluded no benefit and possible detriment in relation to septic complications. In non-acid aspiration of foodstuff, experimental evidence indicates that steroids are contra-indicated, as they interfere with the ability of fibroblasts to wall off foreign material. Most current opinion does not support their use in any form of aspiration.

Prevention

1. Posture

In any unconscious patient at risk, a head down, semi-prone position should be maintained until the patient is intubated with a cuffed endotracheal tube.

2. Suction

Efficient suction must be readily available whenever unconscious patients are being nursed, and the sucker should be at hand during intubation procedures.

3. Cricoid Pressure

During induction of anaesthesia for endotracheal intubation in a patient at risk, cricoid pressure may be lightly applied while the patient is still awake (provided there is adequate explanation), then firmly applied as soon as consciousness is lost. It is important to train staff in its effective and safe application during rapid sequence induction. Awake intubation techniques should always be considered when difficulty with intubation is anticipated.

4. Airway Protection

If patients are unable to protect their airway or spontaneously clear pharyngeal fluids, because of either a depressed level of consciousness or impaired bulbar function, endotracheal intubation should be undertaken. If the problem fails to resolve, then this will need to be replaced by a tracheostomy for long term protection.

5. Nasogastric Tube

Nasogastric tubes must be aspirated regularly (2-4 hours) and left on free drainage as necessary to prevent accumulation of gastric secretions. Fine-bore nasogastric feeding tubes which do not allow suctioning must not be used until gastric emptying is assured. Monitoring of pH with indicator paper identifies those patients at high gastric acid levels, and serves as a routine in the prevention of the stress ulceration syndrome (i.e. maintain pH above 4.)).

6. Antacid Therapy and H2 Receptor Antagonists

Antacid therapy is used in critically ill and peri-operative patients to reduce the risk of acute stress induced ulceration and to reduce the risk of acid aspiration. More recently, these principles have been questioned because of the effects of antacid on gastric colonisation with micro-organism. There are also potentially adverse effects of some antacids if aspirated. Magnesium trisilicate has been a favoured antacid in the peri-operative situation and Intensive Care. However, there is growing concern about its efficacy and safety considering its particulate nature. Particulate antacids may cause or aggravate apsiration pneumonitis in humans and dogs. Studies on dogs suggest that non-particulate antacids (i.e. 0.3 molar sodium citrate) are less damaging and as effective.

H2 receptor antagonists block gastric histamine receptors and reduce the volume of gastric juice by the volume of acid no longer secreted. Cimetidine 300 mg orally the evening before surgery, and repeated intramuscularly at least 1 hour preoperatively, has been shown to effectively reduce the volume of gastric contents and elevate the pH to safe levels during the perioperative period. Although effective intravenously, the duration of action is probably much shorter than the 4 hours reported for oral and intramuscular routes. Haemodynamic problems have been reported with the intravenous route and prolonged use may cause sedation and confusion, thrombocytopenia and inhibition of hepatic enzymes. Ranitidine 50 mg IV has a longer duration of action and may be given 8-12 hourly. It appears to be free of the side-effects encountered with cimetidine, and is thus prefered. Because of the microbial colonization induced by antacid therapy in critically ill patients, the use of antacids in combination with local and systemic anti-microbial therapy, or the use of the cyto-protective agent sucralfate instead of antacids, has been proposed. The effect of these agents on aspiration are not yet known.

7. Metoclopramide

This drug facilitates gastric emptying and also increases the tone of the lower oesophageal sphincter. However, the use of narcotics and atropine counteract these favourable effects.