



Aspiration pneumonitis and aspiration pneumonia in neurologically impaired children

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Introduction

Respiratory problems contribute significantly to the overall morbidity and mortality in neurologically impaired children.¹⁻³ Plioplys³ studied severely disabled children living in institution in United States and found that 77% of deaths were result of pneumonia. Aspiration, either from secretions/food in the pharynx or from reflux of gastric contents, is a very common phenomenon in this group of children.^{1,4} The true prevalence of aspiration pneumonia is difficult to determine because of the vague definitions and varying levels of clinical recognition. Although aspiration syndrome is very common, there remain many pitfalls in its management, including failure to distinguish aspiration pneumonitis from aspiration pneumonia, failure to recognise the spectrum of pathogens, and the misconception that aspiration must be witnessed. A physician survey in a university medical centre⁵ found out that there is divergent approach to the treatment of cases of aspiration with empirical antibiotics frequently initiated to treat noninfectious stages of aspiration. This article will review on the pathophysiology, clinical features and management of aspiration pneumonitis and aspiration pneumonia, with special emphasis on aspects related to neurologically impaired children.

Pathophysiology

Aspiration is defined as the inhalation of material into the airway below the level of the true vocal cords. The inhaled material can be antegrade from swallowed food/nasopharyngeal secretions or retrograde from refluxed gastric content. Aspiration can lead to a group of pulmonary conditions including pneumonitis, pneumonia, airway obstruction, atelectasis, lung abscess, bronchiectasis, lipoid pneumonia, and acute lung injury/acute respiratory distress syndrome (ARDS).

Aspiration is a relative common phenomenon even in normal person. When radioactive substance was introduced into the naso-pharynx of healthy adults during sleep, one study⁶ found that half of them will aspirate small amounts of the radioactive substance. There are various normal defense mechanisms against aspiration. These include the closing of the larynx during swallowing, the upper and lower oesophageal sphincter which protects against gastro-esophageal reflux, and cough reflex which expels the foreign material out of the respiratory tract when chemoreceptors of the respiratory epithelium are stimulated. Aspiration will occur if these protective mechanisms are defective. Some of the conditions associated with increased risk of aspiration include decreased level of consciousness, neuromuscular disease with impaired swallowing, structural abnormalities of the aerodigestive tract, prolonged supine position, endotracheal intubation, nasogastric tube, and vomiting.^{7,8}

In children with neurological impairment, several factors coexist and contribute to the increased rate of aspiration. Many of these children have oropharyngeal motor problems and in-coordinated swallowing. Gastro-oesophageal reflux is also more common and severe in children with cerebral palsy. Refluxed material is more likely to be aspirated because of disturbed esophageal peristalsis and in-coordination between swallowing and breathing. Children with neurological impairment also tend to have weak cough which offer poor protection to the lower airway when aspiration occurs.

Aspiration pneumonitis

There is frequent confusion between the diagnosis of aspiration pneumonitis and aspiration pneumonia.⁷ Aspiration pneumonitis is defined as an acute inflammatory reaction to the aspirated material. It is non-infectious and characterised by an infiltrate on chest X-ray commonly in the dependent bronchopulmonary segment. Posterior segments of the

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upper lobes and apical segments of the lower lobes are commonly involved when a patient aspirate in recumbent position while basal segments of the lower lobes are commonly affected if a patient aspirate in upright position.

Historically aspiration pneumonitis was described as Mendelson's syndrome in obstetric patients who aspirated while receiving general anesthesia during obstetrical procedures. The severity of lung injury depends on the nature of the aspirate: high vs. low volume, acidic vs. neutral pH, particulate vs. non-particulate, contaminated vs. non-contaminated, and virulence of the organism. Usually a pH of 2.5 or less together with volume of gastric aspirate of 0.3 ml/kg is required for the development of aspiration pneumonitis.⁷ However, particulate aspiration can cause severe pulmonary damage even if pH of the aspirate is above 2.5. Gastric contents are sterile under normal conditions because of the acidic environment which prevents bacterial growth. Colonisation of gastric contents by pathogenic organisms may occur if the pH in the stomach is increased, e.g., in patients taking antacids or proton pump inhibitors.

If the aspiration is witnessed, patient should be put into lateral position and the upper airway should be suctioned immediately. In patients who are unable to protect their airways, e.g., patients with impaired consciousness, endotracheal intubation should be considered. Since aspiration pneumonitis is the result of a non-infectious inflammatory process, most authorities agree that prophylactic antibiotics are not indicated.^{7,9} Overuse of antibiotics may select for more resistant organisms in patients with uncomplicated chemical pneumonitis. Antibiotics should be considered when there is likely to be bacterial infection, e.g., when aspiration pneumonitis worsens or fails to resolve within 48 hours after aspiration. Prophylactic corticosteroids were commonly used to treat pneumonitis in the past but studies found that they have no significant effect on patients' outcome and complication rates and is therefore not recommended.^{7,9}

Aspiration pneumonia

Aspiration pneumonia is an infectious process that develops after aspirating colonised oropharyngeal or gastric material. As we have seen, aspiration of small amounts of oropharyngeal secretions during sleep

occurs in many healthy adults.⁵ However, the protective mechanisms of forceful coughing and ciliary movement, the low burden of virulent bacteria and normal immune mechanisms made aspiration pneumonia infrequent in healthy persons. Aspiration pneumonia usually refers specifically to patients who are at increased risk for oropharyngeal aspiration.

In patients with aspiration pneumonia, the episode of aspiration is generally not witnessed. The diagnosis is considered when a patient at high risk of aspiration developed radiographic evidence of pneumonia in a characteristic bronchopulmonary segment. Its diagnosis is confirmed when a protected brush specimen/bronchial alveolar lavage specimen yield pathogenic organism in significant concentration.

Anaerobes are believed to be the commonest organisms in aspiration pneumonia in adults and children.¹⁰⁻¹² Two recent adult studies using protected brush specimen in intensive care setting found that aerobic organisms are more common.^{13,14} However, anaerobic conditions were not preserved during transport in both studies. Also in one study¹⁴ all patients were given Penicillin G before sampling with a protected specimen brush was performed. In community-acquired aspiration pneumonia, aerobic organisms commonly isolated include *Strep pneumoniae*, *Staph aureus*, and gram negative bacilli.¹⁵ If the patient comes from institution or long stay care facility, *Pseudomonas aeruginosa* is also a common organism.¹⁶ A study in children¹¹ using percutaneous transtracheal specimens found that multiple organisms are involved in aspiration pneumonia with mixed aerobes and anaerobes present in 90% of tracheal aspirates. The common anaerobic organisms involved in these children include *Bacteroides melaninogenicus*, *Peptococcus*, *Peptostreptococcus*, *Fusobacterium*, *Bacteroides fragilis*, *Veillonella*, and *Bacteroides oralis* while the common aerobic bacteria include Alpha-hemolytic strep, *Pseudomonas aeruginosa*, *Strep Pneumoniae*, *E. coli*, *Klebsiella* and *Staph aureus*.

In one retrospective study¹⁷ on antimicrobials treatment of aspiration or tracheotomy-associated pneumonia in neurologically impaired children, three groups of antibiotics were used, namely: iv ticarcillin-clavulanate followed by oral amoxicillin-clavulanate, iv followed by oral clindamycin, and iv ceftriaxone followed by oral cefixime. Ceftazidime was added if previous tracheal aspirate culture reviewed *Pseudomonas*. A satisfactory



clinical and microbiological response was observed in 89% and 91% in the first two groups respectively compared with in only 50% in the third group. It was concluded that ticarcillin-clavulanate and clindamycin treated groups had significantly better outcome than the ceftriaxone treated group in these neurologically impaired children. The improved efficacy of clindamycin as well as ticarcillin-clavulanic acid, as compared to ceftriaxone, may be due to their excellent antibacterial activity against penicillin-resistant anaerobic bacteria as over 40% of the common pigmented *Prevotella* sp and *Fusobacterium* can resist beta-lactam antibiotics by producing beta-lactamase.^{17,18} Common antibiotics effective against beta-lactamase producing anaerobes include clindamycin, metronidazole, chloramphenicol, combination of penicillin and a beta-lactamase inhibitor, and imipenem while antibiotics generally not effective against beta-lactamase-producing anaerobes include beta-lactam resistant penicillins, and second and third generation cephalosporins.¹⁷

Antimicrobial therapy is directed at the major pathogens encountered in different patient groups. In community-acquired pneumonia, the usual oropharyngeal flora is most likely involved and treatment with penicillin with or without beta-lactamase inhibitor is a good choice.^{18,19} If aspiration pneumonia occurs in hospitalised or institutionised children with neurological impairment or tracheotomy, a different spectrum of organisms will be involved because of the modified oral flora and prevalence of gram-negative rods in hospital patients. We should take into account of previous culture results which may reveal colonisation by pathogens like *Pseudomonas* and *Klebsiella*. Because multiple organisms may be involved in these groups of hospitalised patients, final antibiotic choice needs to rely on culture results. Pending culture results, a penicillin with beta-lactamase inhibitor plus coverage for gram negative organisms or *Pseudomonas* in previously colonised patient is probably appropriate.^{18,19}

Assessment and management for recurrent/intractable aspiration

Swallowing difficulties are common in neurologically impaired children, especially in children with spastic cerebral palsy. However, evaluation and management of their feeding problem is typically delayed, partly because many of the aspirations are silent aspirations not accompanied by cough or choking and therefore

not recognised. In a study on videofluoroscopic assessment of dysphagia in children with severe spastic cerebral palsy, Mirrett et al⁴ found that the overall incidence of aspiration was 77% while incidence of silent aspiration only is 68%.

Assessment of the cough and gag reflexes is unreliable in identifying patients at risk of aspiration. The clinically observable oral phase of swallowing also does not provide reliable clues as to whether or not the patient is swallowing safely.⁴ A videofluoroscopic swallowing study performed by a speech therapist can provide a clear picture of the entire swallowing process and its safety. During the study patient is given liquid or solid in different texture in different position. Videofluoroscopic images are taken and analysed to assess the various stages of swallowing, including oral preparation, pharyngeal triggering, and pharyngeal clearing/peristalsis. Presence of aspiration and gastro-esophageal reflux can be seen from the images. If a patient is found to have swallowing dysfunction, individualised early intervention can be introduced with the help from the speech therapist. This could be choosing the appropriate texture of food for the patient, reducing the bite size, positioning like keeping the chin tucked and the head turned while feeding etc. Alternative form of feeding like gastrostomy feeding is required in patients who continue to aspirate despite training and using of specific feeding strategies.

Gastrostomy feeding and aspiration

Gastrostomy is frequently done for patients with oral-motor dysfunction and poor oral intake with resultant under-nutrition. Studies have demonstrated that gastrostomy tube feeding has resulted in increased weight gain and subcutaneous fat deposition, reduction in time spent feeding and improved quality of life for carers and is superior to nasogastric tube feeding in delivering nutrition.^{20,21}

However, there is much controversy on the effects of gastrostomy feeding on respiratory symptoms and gastro-esophageal reflux.²¹ Although patients on tube feeding will not aspirate food while eating, they can still aspirate colonised oral secretions or refluxed gastric contents. Two randomised studies^{22,23} have shown that the incidence of aspiration pneumonia was similar when nasogastric feeding was compared with gastrostomy feeding. In a prospective cohort study, Sullivan et al²⁴ found no evidence for an increase in respiratory



morbidity following insertion of gastrostomy tube in children with cerebral palsy and there was a reduction in chest infections in those who had a proven unsafe swallow. A systemic review²¹ on gastrostomy feeding and cerebral palsy found that there is little evidence to conclude whether gastro-oesophageal reflux was increased or decreased with gastrostomy feeding.

Surgical management for intractable pulmonary aspiration

Intractable or chronic pulmonary aspiration is a life-threatening problem. Initial management for recurrent aspiration includes swallowing training, positioning, food texture changes, alternative feeding route like gastrostomy feeding and medications such as anti-emetics, anti-reflux drugs and antibiotics. If all the initial management fails, surgical procedures can be done to tackle the problem.²⁵

Tracheotomy is useful in improving pulmonary toilet in patients with sputum retention. However, it is not satisfactory for prevention of aspiration. The presence of the tube in the trachea may in itself compromise laryngeal elevation during swallowing. For more severe aspiration, more definitive and aggressive surgical intervention, including glottic closure, laryngeal closure, total laryngectomy and laryngo-tracheal separation had been tried with some success.

Takamizawa et al²⁶ reported their experience of laryngotracheal separation for intractable aspiration pneumonia in 11 neurologically impaired children. The procedure of laryngotracheal separation involved dividing the trachea obliquely. The distal end of the trachea was sutured to the skin creating a wide tracheotomy while the proximal trachea was anastomosed to the esophagus or closed. In their study laryngo-tracheal separation decreased the frequency of pneumonia and the frequency of suctioning required and all parents rated the operation as excellent or good in terms of its improvement of quality of life. The authors concluded that laryngotracheal separation can be recommended for neurologically impaired children with intractable aspiration as a primary surgical intervention.

Conclusions

Aspiration and its complications cause significant

morbidity and mortality in neurologically impaired children. Early assessment for risk of aspiration, including the use of videofluoroscopic swallow study, is useful in setting specific treatment goals for each patient. Aspiration should be suspected in a patient with dysphagia and an infiltration in a dependent bronchopulmonary segment. Although there is some overlap between aspiration pneumonitis and aspiration pneumonia, they are two different clinical entities requiring different treatment. Aspiration pneumonitis is a noninfectious inflammatory process and does not need antibiotic treatment. On the other hand, aspiration pneumonia should be treated with antibiotics covering common aerobic and anaerobic organisms according to the prevalence of pathogens in different patient groups.

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