

Review article:

Pathophysiology of aspirated foreign bodies in trachea-bronchial tree:

Review

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Abstract:

Foreign body in the trachea-bronchial tree is an accidental invasion or presence of foreign substance in the tree. It may be solid or liquid in nature, from animal, mineral or vegetable kingdom. It may be endogenous like pus, blood secretions, etc. or exogenous which may be aspirated through natural passages or penetrated through chest wall. Aspiration of foreign bodies in tracheo-bronchial tree occurs mainly in children, between 1 and 3 years of age. The natural tendency of an infant is to put anything into his mouth. He does not expectorate an inedible object as an adult would, but tries to swallow it thereby converting it into a foreign body. Dentition is not complete until the child is over 2 years of age and chewing habits are not established until 4 years of age. Nuts, raw vegetables or fruits require the grinding action of molars for thorough mastication. Consequently children under age of four should not be given foodstuffs that have not been properly cooked or mashed. So there appears a dental factor involved in foreign body aspiration. A foreign body which has entered the tracheo-bronchial tree will either settle down in one of the bronchi or it will remain in the trachea or settle down over carina. Right main bronchus is the site of predilection for most of the bronchial foreign bodies.

Keywords: trachea-bronchial tree , foreign bodies

Background:

Aspiration of Foreign bodies in respiratory passage presents as a grave emergency, unless diagnosed and treated promptly, a fatal outcome becomes almost inevitable. Foreign body in the tracheobronchial tree in childhood is one of the most common emergencies encountered in the ENT practice and in neglected cases, may lead to fatal outcome. ¹The presentation of occult foreign body is complex and the diagnosis of such foreign body claims most minute attention. ²Foreign bodies are classified as animate and inanimate. Animate are maggots, screw worms, black carpet beetles. Inanimate are vegetable foreign

bodies like peas, beans, dried pulses, nuts, paper, cotton, wool and piece of pencil. Mineral matter may be parts from metal and plastic toys, washers, nuts, nails, buttons, sponge, pebbles and beads, Surgery like polyps, bone and cartilage. ³Fragmented pieces of groundnut and grams are more common objects. Check valve type of obstruction leading to emphysema on X-Ray chest, on the affected side, while mediastinum is shifted to normal side and the pulmonary area of affected side becomes relatively less than normal. The symptoms and signs due to foreign body aspiration depend upon the nature, size, location and time since lodgement of the foreign

body. A large foreign body occluding the upper airway completely is an immediate threat to life while smaller objects lodging in smaller bronchi may cause less severe symptoms. Foreign body in bronchus leads to various presentation in the lungs. Collapse of the segment or the whole of the lung on affected side is a fairly common pathology.⁴

Aspiration of FB into the tracheobronchial tree is a medical emergency and sometimes results in sudden death. More than 75 % of cases of aspirated FB occur in children aged less than 3 yrs. FB inhalation is usually accompanied by severe coughing, wheezing, dyspnoea and stridor. This acute episode may escape the notice of parents, and the cause may be obscured for a long period. Radiology is the primary means of confirming the diagnosis. However, it is seen that most FB are radiolucent. Chest roentgenograms are frequently normal if taken immediately after the FB inhalation and findings of obstructive emphysema and atelectasis are not always present. Great advances in endoscope and anesthetic techniques, have greatly reduced the trauma and complications previously associated with endoscopic removal of tracheobronchial FB. ⁴Laryngotracheal FB although less common than bronchial FB, are potentially dangerous.^{5,6}

Pediatricians are aware of the symptoms of inhaled FB in the lower respiratory tract. However, symptoms suggestive of FB in the larynx do not appear to raise the same index of suspicion in case of bronchial FB. Where the diagnosis of FB is unclear, chest and airway radiograph supplemented by fluoroscopy can increase the ratio of correct and early diagnosis. Fluoroscopy should be universally accepted as an initial diagnostic technique in laryngotracheal FB evaluation. Long standing FB is associated with considerable morbidity. CT scan is

recommended for suspected FB where conventional methods fail to make a diagnosis⁵

Review:

The earliest treatment of an upper airway foreign body consisted of a tracheostomy and there are references to this procedure in ancient Hindu medicine between 2000 & 1000 B.C. Heister (1718) removed a piece of mushroom from the trachea of a man via a tracheotomy route.⁷ Desault (1810) at Paris, was the first to open up the larynx by splitting thyroid cartilage, in a patient whose larynx had an impacted foreign body. Joseph O'Dwyer (1890) devised a tube of large caliber and thin walls from the expulsion of foreign bodies of the larynx and trachea. The tube was inserted into the larynx and the foreign body was extruded by making patient cough violently.^{8,9}

The first bronchoscopic removal of a foreign body from the lower air passages is attributed to Gustav Killian "(Father of Bronchoscopy)" in 1897. ¹⁰He succeeded in removing an aspirated pork bone from the bronchus of a 63 year old farmer under local (cocaine) anesthesia he used an external light source and was first to employ a head mirror for his bronchoscope. Algernon Coolidge (1891) became the first American to remove a foreign body from the endobronchial tree using an open urethroscope, a head mirror and reflected sunlight.¹¹

Jackson & Jackson (1951) in an analysis of 3112 cases accurately and elaborately recorded as to the causative factors and classified them as follows:¹²

1. Personal factor such as age, sex, occupation (work or play), social condition and place of residence.
2. Failure of patient's normal protective mechanism, including sleep, alcoholic

incoordination, epileptical seizure and unconsciousness.

3. Dental, medical and surgical factors.
4. Psychopathic and psychotic factors.
5. Properties of the form of putting inedible substance in the mouth.
6. Carelessness in the form of putting inedible substance in the mouth, hasty eating and drinking.
7. Permitting children to play while eating
8. Giving peanut candy to the children in whom the molars have not yet erupted.

He further mentioned that if one put in to his mouth nothing but food, foreign body accidents would be rare.

Kassay (1963) had reported that habit of almost every child and some adults of placing small objects in the mouth which may slip into the pharynx, and are inhaled into the lower airways by the airflow of the forced inspiration. Fright, crying, coughing and laughing are accompanied by quick deep inspiration. This type of rapid strong airflow may carry a foreign body through the glottis into the trachea and bronchus.¹³

Dannilidis et.al (1997) observed the following causative factors responsible for foreign body inhalation.¹⁴

1. Anatomic relation of the larynx in children.
2. Difficulty in chewing due to lack of wisdom teeth.
3. The habit of most children to put everything into the mouth.
4. Shouting, crying and playing during eating.

Rothmann and Boeckman (1980) reported that children in the first 3 years of life are partially edentulous and have a tendency to place any object in the mouth.¹⁵

Chung –Hua Chen et.al (1997) analyzed adult patients and stated that, normally swallowing reflex protects human subjects from foreign body aspiration into the airway, in adults when this mechanism can not operate normally or when the foreign body bypass this reflex in the oropharynx, it will be easily aspirated.¹⁶ The former includes CNS dysfunction due to stroke, metabolic encephalopathy, alcoholism, sedatives, mental retardation, seizure etc. Condition that bypass the reflex include intubation, dental procedure, facial trauma, gastroesophagal reflux etc. underlying pulmonary disease and poor pulmonary function reserve may cause foreign body aspiration due to the need of rapid respiration leading to discordance between the swallowing centre and respiratory centre.

Patho-physiological changes:

Jackson & Jackson (1937) reported that pathological changes in cases of exogenous foreign bodies on the character, size, shape of the foreign body and the site and duration of its sojourn in tracheobronchial tree. He summarized the pathological changes as follows:¹³

1. A smooth metallic non-obstructive foreign body will produce at most, only slight local congestion of vessels in the part of mucosa.
2. A rough metallic obstructive foreign body or if and when it acquires these qualities by corrosive causes localized inflammation and mucosal swelling causes occlusion of the bronchus. Shortly after occlusion of a bronchus, segmental or entire lung collapse occurs. If this persists for many weeks, infective mucosal inflammation begins in the atelectatic areas, because of lowered resistance resulting from lack of ventilation and drainage.

3. In case of vegetable foreign body, there is a violent reaction in the mucosa, a vegetable bronchitis (arachidic bronchitis) starts within few hours in babies and within a day or two in 2 years' old children. In some cases granulation may form within two weeks

Nathan E Wiseman (1984) in a series of 157 children with foreign body aspiration, classified the severity of endobronchial inflammation at the time of bronchoscopy as absent, mild or severe, based upon the presence of erythema, edema, granulation tissue and purulent secretion ninety six percent of patients diagnosed early (within 24 hours of inhalation) had absent or mild bronchial inflammation whereas 36% of patients diagnosed late (beyond 24 hours) had severe bronchial inflammation.¹⁷

Ishii et.al (1993) reported a 46 years old male having inhaled a denture fragment in the right bronchus one and half year ago.¹⁸The rigid bronchoscopic removal of the foreign body was associated with massive hemorrhage due to disruption of pulmonary artery and other vessels close to the foreign body, and the granulation tissue around the foreign body.

Mechanism:

Jackson and Jackson (1951) reported four types of obstruction due to foreign body namely:¹⁴

Type – I By-pass Valve: This occurs with foreign bodies which partially obstruct the lumen in both phases of respiration with reduction in ventilation past it. The involved lung field shows diminished aeration and opacity, without any marked mediastinal shift.

Type – II Check Valve: This type of obstruction allows ingress of air during inspiration but not during expiration with consequent obstruction emphysema. The trachea and the cardiac shadow are shifted to the opposite side and the dome of the diaphragm is

depressed. The picture develops rapidly during the early stages of an obstruction.

Type-III Stop Valve: This may occur in two ways and associated with obstruction of air passage in both inspiration and expiration. It may occur when a large foreign body causes total occlusion from the of inhalation, or it may develop in what had previously been a check valve type of obstruction after a vegetable foreign body swells up and consolidation of the affected bronchopulmonary segment

Type – IV Ball Valve: this type is associated with foreign bodies such as peas, beans, or rounded smooth, metallic bodies such as pellets. In such cases, the foreign body is dislodged by the passage of air during expiration but re-impacts during inspiration. This type of obstruction, therefore leads to early atelectasis and gives rise to an X-ray picture somewhat similar to that seen with a stop valve obstruction. In these latter cases, therefore the mediastinal shift will be towards the affected site and the dome of the diaphragm elevated.

It is well known that foreign bodies in the air passages may change their position. In these cases both the clinical signs and the X-ray picture may totally change and fresh X-ray must always be taken just prior to the attempted removal. Since the clinical signs are not totally reliable chest X-ray in both inspiration and expiration should always be taken in both postero-anterior and lateral views.

Clinical features:

The classical diagnostic triad of cough, unilateral wheezing and ipsilateral diminished air entry are observed in most cases of bronchial obstruction due to foreign body. Shifting of signs from one side to other is almost diagnostic of foreign body.

Jackson (1915) : noted the following pathognomic systems of tracheal foreign body these include

audible slap, palpatory thud and asthmatoïd wheeze . The also noticed tracheal flutter in a patient with watermelon seed lodged in trachea. Cough, hoarseness, dyspnea and cyanosis are often present. Similarly he reported symptoms of foreign body bronchus. Initial symptoms are choking, gagging, coughing and wheezing followed by symptomless interval. After the symptomless interval, cough, blood streaked sputum, metallic taste or special odour of foreign body may be noted. Vegetable foreign bodies at once cause violent laryngotracheo bronchitis with toxæmia; cough and irregular fever bodies in months, years produce changes which cause fever, chills. Sweats, emaciation, clubbing, hemoptysis, foul expectoration and in fact all the symptoms of chronic pulmonary sepsis, abscess and bronchiectasis.

Holinger (1962) stated that the lodgement of the foreign body in trachea bronchial tree will produce a greatly varied symptomatology depending upon its site, size, shape, character and length of its sojourn, the age of the host and relative area of lung involved.¹⁹Dannilidis (1977) in his series of 90 cases reported that 26 cases were hospitalized within 24 hours, 23 cases within 2 days and other during 4 months. They found two phases of symptomology. The short phase of acute dyspnea. They concluded that factor that causes delay in seeking the specialist's advice are:²⁰

Parental negligence and misdiagnosis by the family doctor. Lack of symptoms after the acute the acute first phase of dyspnea which may go unnoticed in some cases. The diversity of the clinical picture caused by the inhalation of foreign body. Ihglis et.al., (1992) reviewed 173 cases and found that the classic diagnostic triad of cough, wheezing and unilaterally diminished breath sounds was present in 65% of cases. Three patients, less than 2%, presented in acute

respiratory distress. One had bilateral bronchial foreign bodies. Forty nine percent of patients received diagnosis within 1 to 31 days after the onset of symptoms in 42% and 9% did not receive diagnosis within 30 days of presumed aspiration.²¹

Saoji et.al., (1995) reported 6 children with a foreign body in the airway presenting with progressive subcutaneous emphysema and pneumomediastium as a clinical feature.²²They concluded that these unusual clinical presentation results due to a peculiar arrangement of fascial planes in the neck, chest and abdomen and an excessive pressure gradient at the alveolar level with subsequent rupture, facilitate extra alveolar migration of air in the subcutaneous tissue. Treatment of choice for a foreign body when suspected or diagnosed clinically and/or radiologically in the trachea-bronchial tree is endoscopic examination and removal. Jackson & Jackson that treatment by watchful waiting for spontaneous expulsion, by hanging the patient up by his heels, slapping on the back, and blind attempt at the removal has been relegated to a place in the history of archaic medical curiosities. Under modern methods of treatment if a foreign body is located in the trachea-bronchial tree should be removed per orally by endoscopy. It has been observed that fortunately the foreign body may be coughed out, but the incidence of spontaneous expulsion is rare around 2% (Negus 1948 : Jackson & Jackson 1951 : Pyman 1971 : Rothmann and Boeckman 1980 : Black et, al 1984)^{23,24,25}

Rothmann and Boeckman (1980) in a series of 225 patients removed the foreign body by bronchoscopy or laryngoscopy under general anesthesia in 93% of the patients. Lobectomy or segmental resection was performed in 4 patients. Three patients required thoracotomy and

bronchotomy for removal of a distal foreign body. Mc Guirt et,al (1988) in a series of 88 patients recommended that a rigid, rather than flexible, endoscope should be used for removing aspirated foreign bodies. The rigid ventilating bronchoscope combined with the telescopic magnification provides superior visualization and assures adequate ventilation. They also stressed that once the initially suspected foreign body is located and removed, it is imperative that the entire airway be re-examined for the existence of other, simultaneous foreign bodies.

Monden Y et. al (1989) in a series of 27 patients successfully removed bronchial foreign bodies in 81% of all cases with the flexible bronchoscope. They also removed the foreign bodies in young children in 82% (9/11 cases) who were of 2 years or less in age and concluded that the flexible bronchoscope is useful for foreign bodies in the

airway even in young children. For the removal of foreign bodies under the flexible bronchoscope, a biopsy forceps and Fogarty catheter were effective. Boelcskei et. al (1995) used Nd:YAG laser in a 19 months old patients to weaken and cut the aspirated chicken bone in the bronchial tree which was subsequently removed with a regular biopsy forceps obviating the need for thoracotomy. Seventy four percent were removed by flexible fibreoptic bronchoscopy. Four patients received rigid bronchoscopy (RB) after failure of FFB and it was successful in two patients. Of the two RB failure cases, one received surgery and other spontaneously expectorated the foreign body post -RB. For extraction of foreign bodies, accessory instruments included biopsy forceps (cup of alligator forceps) , basket, loop, electromagnet etc. Nd: YAG laser was used to evaporate the granulation tissue.

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