Outcome of acid ingestion related aspiration pneumonia

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Abstract

Background: The objective of this study is to assess the incidence and long-term results of a rarely discussed medical problem – aspiration pneumonia resulting from the intentional ingestion of acid. Materials and methods: The medical records of 370 patients treated at one tertiary care institution for corrosive acid injury during a 12-year period were reviewed retrospectively. The study subjects included any patients who were found to have acid ingestion related aspiration pneumonia confirmed by chest film within 24 h of injury. All available data of these patients with or without aspiration pneumonia were analyzed. Results: Of the 370 patients with corrosive acid injury, 15 (4.2%) had acid-aspiration pneumonia which was related to their intentional ingestion of a strong acid, hydrochloric acid (pH < 1). The data for 14 patients with aspiration pneumonia and 268 without aspiration pneumonia was complete and available for analysis. Patients with aspiration pneumonia were found to be significantly older (52.2 ± 6.2 to 41.7 ± 0.9 years old, P = 0.017), had a higher incidence of nasogastric tube irrigation (35.7–6.0%, P = 0.000), had more conscious disturbance (50.0–17.5%, P = 0.016), and required more endotrachal tube intubation (50.0–3.0%, P = 0.000). Aspiration pneumonia was found to significantly increase the mortality rate in acid injured patients who required emergency abdominal surgery (87.5–32.0%, P = 0.000) and in those who did not (28.5–5.1%, P = 0.05). Two of the six survivors of aspiration pneumonia later developed laryngeal sequelae. Conclusions: Aspiration pneumonia rarely occurs as a consequence of acid ingestion. When it does occur, it greatly increases the mortality rate of those involved. For those who survive, physicians can expect some laryngotracheal sequelae in long-term follow-up. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Aspiration pneumonia; Acid-corrosive injury

1. Introduction

The term aspiration pneumonia covers a spectrum of inflammatory pulmonary disorders that account significantly for the morbidity and mortality in anesthetized patients and unconscious patients with stroke, brain trauma, drug-overdose, alcoholism, or other causes [1–8]. Mendelson (1946) first described the importance of the pH of aspirated fluid as a clinical entity, indicating that hydrochloric acid in gastric juices was among the major causes of severe pulmonary damage [8]. Animal studies have revealed that acid pH, ranging from 1.8 to 2.5, and/or large volumes instilled into the lung would induce severe pulmonary parenchymal destruction [1–7]. In a similar animal study by James, acidic aspirates (0.3 ml/kg; pH 1) of relatively low volume were associated with high mortality rates in rats [9]. In Taiwan, suicide is often attempted by ingesting toilet cleaners containing hydrochloric acid (HCl; pH < 1), which may cause corrosive injury to the upper gastrointestinal tract. Early aspiration of these strong acids during ingestion might occur concomitantly with resultant pulmonary sequelae. Although pneumonia caused by gastric juice aspiration has been well documented in both animal experiments and clinical studies, acid ingestion related aspiration pneumonia has rarely been reported in the literature. To obtain a better understanding of its incidence and consequences, we reviewed our clinical experience with acid ingestion related aspiration pneumonia in this study.

2. Materials and methods

2.1. Patient selection

The medical records of patients treated for acid-corrosive injury at the National Cheng Kung University Hospital during the period June 1988 to May 2000 were reviewed. Individuals diagnosed with aspiration pneumonia, confirmed by chest roentgenography (CXR) within 24 h of the injury,
were enrolled in this study; those developing pneumonia after 24 h were excluded. Radiographic manifestation of aspiration was based on Landay’s (1978) classification [10].

2.2. General management principles for acute acid-corrosive injury

During the acute stage of acid-corrosive injury, clinical and laboratory evaluations, which consisted of complete blood counts, leukocyte differential counts, arterial blood gases (ABG), blood biochemistry, and a routine CXR study, were conducted in the emergency room (ER).

All patients were treated conservatively except when surgery was required. Conservative medical management included fasting, nasogastric (NG) tube decompression, intravenous fluid replacement, correction of pH imbalance, and antibiotic administration (second generation cephalosporin and aminoglycoside). Esophagogastroduodenoscopy (EGD) was routinely performed on the patients, who did not require emergency surgery, in order to predict the prognosis of alimentary tract injury. Indications for surgery included massive gastrointestinal bleeding, frank peritonitis or generalized abdominal tenderness on serial physical examinations, and pleural effusion, pyopneumothorax, or pneumoperitoneum determined by radiographic examination. If the pH was \( < 7.0 \) or the base deficit \( > 16 \text{ mmol/l} \) on initial ABG, early exploratory laparotomy was considered. Based on the extent of injury, surgical procedures included esophagegastroectomy, with or without duodenectomy, and partial jejunectomy. Cervical esophagostomy and feeding jejunostomy were performed concomitantly. Gastrostomy with concomitant jejunostomy was reserved for patients without noticeable frank hollow-organ perforation. Exploratory laparotomy, with no additional procedures, was reserved for patients with such extensive injury that surgical resection was precluded. Patients who underwent surgery also had a CXR immediately after surgery and on the first postoperative day.

2.3. Specific care for patients with aspiration pneumonia

For those patients with persistent respiratory distress and/or severe disturbance of consciousness, endotracheal intubation was done immediately if they were on oral suction and oxygen. Mechanical ventilation was provided if hypoxemia persisted. Bronchoscopy was performed in ER when CXR or chest-physical examination led to the suspicion of gastric-particle aspiration [11]. During hospitalization, repeated flexible/rigid bronchoscopy was performed to remove tracheobronchial granulation or tenacious sputum.

2.4. Statistical analysis

To investigate the predictors of acid ingestion related aspiration pneumonia, we analyzed the patient data, including age, sex, time interval from injury to ER, mental status of the patients, shock (systolic blood pressure \( < 90 \text{ mmHg} \), shock index \( \geq 1 \) (Pulse rate/systolic blood pressure \( \geq 1 \)), history of NG tube irrigation, initial laboratory data (complete blood count and leukocyte differentiated count, platelet), and initial arterial blood gas (pH, \( \text{PaO}_2 \), \( \text{PaCO}_2 \), \( \text{HCO}_3^- \), base deficit) taken in the ER. All continuous data were expressed as mean \( \pm \) standard deviation (SD). Continuous data were analyzed with Student’s t-test, and categorical data were analyzed with chi-square test. A \( P \)-value of \( < 0.05 \) indicated statistical significance.

3. Results

3.1. Incidence of acid alimentary tract injury and acid-aspiration pneumonia

Of the 370 patients with a history of acid ingestion resulting in corrosive injury, 90.2\% were characterized as incurring esophageal injury, 89.6\% injury to the stomach, and 59.2\% duodenal injury. Sixty-one patients required emergency surgery as a result of esophagogastric complications: five underwent gastrostomy with jejunoostomy, 31 underwent esophagogastrectomy, 16 underwent esophagogastroduodenectomy, and nine underwent exploratory laparotomy. Seventy-four patients developed esophageal stricture, with or without gastric stricture, and required dilatation or reconstruction. Thirty-nine patients had isolated gastric bleeding or stricture and required surgery at the subacute or chronic stage. Only 15 (4.2\%) of the 370 patients developed aspiration pneumonia within 24 h following ingestion.

3.2. Patient characterization

The selected patient group consisted of three males and 12 females, with ages ranging from 17 to 82 years with an average age of 52.2 years. All patients had ingested solutions containing HCl (pH \( < 1 \)). Their mental status in the ER, surgical procedures, CXR findings, location of lesions, courses of hospitalization, as well as their late sequelae are summarized in Table 1. Endotracheal intubation was required for all patients with bilateral perihilar or dual-lobe involvement.

3.3. Roentgen presentation

All patients, except one, developed pulmonary infiltration, as revealed from initial chest film. Bilateral-lower-lobe and perihilar involvement were the most prevalent types of injury. Iatrogenic misplacement of the NG tube into the tracheo-bronchial tree was the main cause for aspiration pneumonia in patient number 13, who subsequently developed left-lower-lobe pneumonia.

3.4. Predictors of occurrence of acid aspiration

The complete data of 282 out of 370 patients, including 14 with aspiration and 268 without aspiration was analyzed. The analyses with significant differences are summarized in...
Table 2. The data included time interval from injury to ER, complete blood count, platelet, shock or shock index $^1$, and PaCO$_2$ of ABG showed no differences between the aspirated and non-aspirated patients.

3.5. Anatomo-pathology of laryngotracheal injuries in patients with acid-aspiration pneumonia following acid ingestion

Bronchoscopy was not performed in ER in this study. Retrospectively, emergent EGD provided the information of laryngeal injuries in four (4th, 11th, 12th, 13th) of 15 patients with aspiration. These four patients were noted as having edema and whitish exudative coating of epiglottis, aryepiglottic folds, corniculate tubercles, and vocal cords. Two of the four patients were also found to have deep ulceration in the same areas. After admission, patient number 6 underwent repeated bronchoscopy to evaluate the state of the tracheobronchial tree. The bronchoscopic findings of this patient on the 12th day of hospitalization showed edema and exudative coating of epiglottis. In addition, the lower trachea and bilateral main bronchus had exudative coating, erythema, and much granulation tissue. Subsequent bronchoscopic findings on the

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46th day revealed moderate stenosis of the right upper lobe bronchus and moderate inflammation accompanied by mild granulation of the lower trachea.

3.6. Outcome

Aspiration was directly related to the deaths of five patients, and contributed to the deaths of other four patients. One patient suffered from tracheo-bronchial granulation. Although she underwent repeated bronchoscopic removal of granulation tissue, she expired 7 days after removal of tracheostomy as a result of sputum impaction. The follow-up period ranged from 1.5 to 8 years with all but one survivor doing well. Patient number 13, the one who had the iatrogenic-misplaced NG tube, was lost to follow-up 1 month after admission. The incidence of laryngeal or tracheo-bronchial sequelae in our 370 patients following acid-corrosive injury was 1.1% (4/370). Three of these four patients had aspiration pneumonia. One of the three aspiration pneumonia patients developed destroyed epiglottis sequel and underwent esophageal reconstruction 4 months after injury. At the time of the reconstruction, he started having choking symptoms that did not subside until 1.5 years after the injury. Another patient, who had vocal-cord adhesion and underwent repeated laryngeal microsurgery, had her tracheostomy tube uneventfully removed 1 year later.

4. Discussion

Since individuals who attempt suicide are typically conscious and lucid, concomitant aspiration pneumonia rarely occurs in acid-corrosive injured patients. In this study we only enrolled the patients with aspiration pneumonia of acid that occurred either during or immediately after acid ingestion. The management of these patients is quite different from those of individuals whose aspiration developed after the injury. As the time passes, risk of aspiration greatly increases because of salivary retention in the oral cavity due to swelling and inflammation of esophageal orifice after acid injury. However, saliva aspiration can be easily managed and rarely causes pneumonia with complications [4,5].

Four factors make one prone to aspiration via ingesting acid: (1) rapid ingestion of a large volume of acid fluid, which is probably the major reason that such patients have more acidemia (lower pH, $\text{HCO}_3^-$ and higher base deficit) on ABG and high incidence of requiring emergency surgery; (2) laryngeal dysfunction among the elderly, as patients who had aspirated acid were significantly older than the others; (3) the hold of acid in the mouth prior to swallowing, which would lead to the choking on one further mouthful of acid into the trachea and increased the severity of laryngeal injury and risk of laryngotracheal sequel; and (4) NG-irrigation induced vomiting, as our data revealed NG-irrigation to be a risk factor in the aspiration of acid. In most cases, the aspiration of acid was probably the result of a combination of these mechanisms.

The current management protocol we follow in the treatment of patients with concomitant aero-digestive corrosive injury is as described in Fig. 1. Our first priority is to keep the airway patent. Our study showed that most patients who had saliva pooling induced respiratory distress could be treated with oral suction and oxygen. Some patients who had persistent hypoxia and/or severe conscious disturbance require immediate endotracheal intubation, and concomitant aspiration pneumonia induced respiratory distress and conscious disturbance required early ventilatory support. Other reasons for requiring endotracheal intubation and early ventilator support included severe intra-abdominal injuries and the patient’s concomitant use of sedatives or alcohol. We have found the use of CXR in the ER to be the best method of detecting acid ingestion related aspiration pneumonia because roentgenographic manifestations of aspiration tend to develop early after acid injury [5,7,12]. Bronchoscopy is also efficacious in the detection of aspiration. Although it had not been routinely performed in our patients with acid aspiration at the time of the study, we agree that it should be performed when CXR or physical examination is suggestive of gastric-particle aspiration [2,4,5,11]. Obviously, bronchoscopy would be able to show the injury pattern of larynx, which would be useful for predicting laryngeal sequelae. The EGD examination is another alternative method of examining the larynx, particularly when it is used to evaluate injury severity in the upper alimentary tract.

Following endotracheal intubation, the second important issue in the management of these patients is the decision whether to perform abdominal surgery or not. Although prognosis of patients requiring emergency surgery mainly depended on the severity of alimentary tract injury, our data revealed that concomitant aspiration pneumonia greatly increased the risk of death. We believe that it would be best to preserve pulmonary function to lessen the probability of aspiration pneumonia becoming a cause of death or a contributing factor. Patients requiring surgery lost an extensive amount of body fluid perioperatively. Though ventilator support with positive end expiratory pressure [13,14] is beneficial for injured lung, early hypertonic fluid resuscitation [14,15] with albumin supplementation [16] is mandatory. The latter not only compensates for the loss of fluids but also prevents further damage by excessive fluid to the permeable injured lung. The outcome of patients who did not require surgery mainly depended on the severity of lung injury. For instance, clinical course of patients who had acinar-nodule characteristic of bilateral perihilus, which resembles pulmonary edema, was generally benign. Although all patients found to have bilateral perihilar nodules on CXR required endotracheal intubation in the ER, those who survived could be extubated within 3 days. Also, evidence of their lesions subsided on CXR within 7 days. In contrast, patients with bilateral lower-lobe or bi-lobes involvement had poor prognoses. Following this type
of injury, the patients developed adult respiratory distress syndrome, which has a mortality rate of around 90% [4,17], even when there was no presence of acid alimentary tract injury. To improve the outcome of such patients, hypertonic solution supply [14–16], intra-tracheal supplement of surfactant supplement [18,19], and the assistance of extracorporeal membrane oxygenation (ECMO) [20,21] have been recommended. However, the use of ECMO should be carefully considered. In our study, postoperatively, patients who had undergone emergency surgery usually still had many raw surfaces in the abdominal cavity, which could easily start bleeding again. Some patients who did not require emergency surgery developed massive gastric bleeding in the subacute stage. Gastric bleeding usually occurred 8–10 days following injury, which was about the time when ECMO was used for ARDS treatment. Heparinization, required for ECMO, might increase the risk of intra-abdominal or gastric bleeding.

Patients who had aspirated acid but had no signs of respiratory distress usually presented with productive cough and/or localized wheezing. Hoarseness, which is caused by laryngeal injuries, was a specific indicator of acid aspiration. In such patients, pneumonia usually resolved without pulmonary sequel unless subsequent infection occurred. For patients

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**Fig. 1. Management protocol of combined acid injury to the aero-digestive tracts.**

- PEEP: positive end expiratory pressure.
- Conservative treatment includes oxygen supply, chest hygiene therapy.
- Adequate fluid management: hyperosmolar fluid should be used including hypertonic saline, albumin, etc.
- *ECMO*: Extracorporeal membrane oxygenation.
who did not require emergency abdominal surgery, oral intake was postponed until laryngeal edema subsided, which usually required 7–10 days. Although some authors have recommended steroid for acid aspiration [1,15,16], we preferred not to use it, because during the acute stage of acid alimentary tract injury, steroid treatment will mask positive signs of hollow-organ perforation.

Unlike alkalis, acid ingestion is said to rarely cause laryngeal or tracheobronchial sequelae. However, we found that the patients with a history of acid ingestion related aspiration pneumonia was prone to having laryngotracheal sequelae and that laryngeal injury did occur in the patients with aspiration pneumonia. As multiple esophageal ulceration would induce esophageal stricture, laryngeal sequelae would be expected if multiple ulceration was noted in the larynx. Particular attention should be paid to a patient’s lowered threshold for choking following reconstruction and to episodes of dyspnea during the chronic stage of the corrosive injury, as laryngotracheal sequelae might occur in both the above conditions. Although acid aspiration has been reported to cause extensive mucosal damage of trachea but without late sequel [22], we did have a patient who developed tracheobronchial sequelae. Therefore, bronchoscopy should be repeatedly performed to keep track of the tracheobronchial tree, especially in cases of long-term pneumonia or prolonged use of ventilator.

5. Conclusions

While early aspiration pneumonia rarely occurs as a consequence of acute acid ingestion, its occurrence greatly increases mortality. Aspiration pneumonia should be suspected in older patients with the presence of respiratory distress or conscious disturbance and a history of NG-irrigation. We also conclude that CXR is a good detector of this entity in ER and that careful observation for late laryngotracheal sequel is necessary during long-term follow-up.

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References