Clinical Characteristics and Outcome in Adult Patients with Pneumococcal Empyema

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Background: Pneumococcus is the leading cause of pneumonia. However, little data exists concerning the clinical characteristics and risk factors associated with pneumococcal empyema, a common complication of pneumococcal pneumonia.

Patients and Methods: This study retrospectively reviewed the data of 20 adult patients with culture-proven pneumococcal empyema who were hospitalized at Chang Gung Memorial Hospital, Taipei, from November 1998 to May 2005. Baseline characteristics, underlying diseases, outcome parameter and antibiotic insusceptibility rates were analyzed. Additionally, outcome parameters for 2 groups— the community-acquired empyema (CAE) group (n=12) and the hospital-acquired empyema (HAE) group (n=8)—were compared.

Results: Patients with HAE had a higher pulse rate, higher pH value and lower PaO2 of arterial blood gas than the CAE patients (p=0.073, 0.024 and 0.055, respectively). Malignancy, which was the most common underlying disease for both groups, was more common in the HAE group (87.5%, n=8) than in the CAE group (33%, n=12) (p=0.017). The most common malignant diseases were lung, head, and neck cancer. Duration of parenteral antibiotics therapy, duration of fever, and duration of hospital stay were longer in the HAE group than in the CAE group (all p <0.05, respectively). The antibiotic insusceptibility rates of penicillin, cefuroxime, ceftriaxone and vancomycin were not significantly different between the CAE and HAE group (all p>0.2).

Conclusion: Patients with HAE had poorer outcomes than those with CAE. Underlying malignancies were a major risk factor for HAE. ***(Thorac Med 2006; 21: 413-421)***

Key words: pneumococcal empyema, pleural effusion, malignancy, antibiotics, susceptibility

Introduction

Streptococcus pneumoniae, the most common bacterial pathogen causing community-acquired pneumonia in both adults and children, results in an estimated 500,000 cases of pneumonia each year [1]. The pneumococcus (*Streptococcus pneumoniae*) is also the most common etiological agent in community-acquired pneumonia in adult hospitalized patients in Taiwan [2], and is the leading cause of hospital-acquired pneumonia in hospitalized patients not in inten-

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sive care unit (ICU) [3].

In a previous clinical study, 4.5% of adult patients developed culture-proven empyema after pneumococcal pneumonia [4]. In hospital-acquired cases, empyema also frequently occurred after chest surgery or thoracocentesis, or due to a subdiaphragmatic pathogenic condition or congestive heart failure complicated with aspiration pneumonia [5]. Thoracic empyema has an overall mortality rate of up to 20% [6]. Despite increasing antimicrobial resistance, little data exist regarding the risk factors for pneumococcal empyema. A previous study indicated that hospital-acquired empyema (HAE) has a higher mortality rate than community-acquired empyema (CAE) [5]. However, data elucidating the different clinical characteristics of CAE and HAE are limited. Some studies showed that malignancy is a common underlying disease among patients with invasive *Streptococcus pneumoniae* infection [7]. No study has determined whether malignancy predisposes patients to respiratory tract and pleural infection, or even the malignancies that are likely related to pneumococcal empyema.

This study compared the initial clinical characteristics, underlying diseases, antibiotic susceptibility, treatment and clinical outcomes of community-acquired empyema (CAE) and hospital-acquired empyema (HAE) caused by *Streptococcus pneumoniae*. This study also describes the characteristics of cancer patients with pneumococcal empyema.

Patients and Methods

Data was obtained for 20 patients, aged 18 or older, with pleural effusion and culture-proven pneumococcal empyema, and hospitalized at Chang Gung Memorial Hospital, Taiwan, between November 1998 and May 2005. Cases were chosen according to the availability of patient charts. The data was representative of the first presentation of pneumococcal empyema for all patients. CAE was defined as an acute infection in the pleural space diagnosed within the first 48 hours of admission. HAE was defined as thoracic empyema that occured >48 hours after admission—not incubating at the time of admission.

Pleural fluid specimens were obtained using thoracocentesis or during tubal thoracotomy. Pneumococcal empyema was considered present when a finding of pleural effusion on a chest radiograph was coupled with any of the following: culture or Gram staining of pleural fluid positive for *Streptococcus pneumoniae*; pleural fluid with a pH of <7.2; a lactate dehydrogenase level of >1000 IU/mL; glucose level of <20 mg/dL; protein level of >3000 mg/dL; and/or white blood cell count (WBC) of >50,000 cells/mL [8-9].

Susceptibility of isolates to penicillin, cefuroxime, ceftriaxone was determined by microdilution. Susceptibility to vancomycin was determined by the disk diffusion method, according to the National Committee for Clinical Laboratory Standards, 2000. Isolates in the intermediate or resistant categories were considered non-susceptible.

The following data were collected for each patient: age; predisposing factors including important underlying diseases and associated medical conditions; vital signs on arrival; hematological and biochemical investigative results; pathogens isolated from effusion specimens; treatment details, including the regimen and duration of antibiotic therapy, and invasive drainage procedures and surgery; and patient outcome, including duration of antibiotics therapy, closed drainage, fever, ICU stay, and hospital stay.

Statistical analysis was performed using

SPSS 10.0 for Windows and GraphPad Prism 4. Continuous variables were compared using the Student's independent samples t- test. Proportions were compared using the chi-square test (2-tailed, confidence interval (CI) 95%). A value of $p<0.05$ was considered statistically significant.

Results

Twenty adults, 15 males (75%) and 5 females (25%), were enrolled in this study. No subject had a documented history of pneumococcal vaccination or a stay in a nursing home. Twelve (60%) subjects had CAE and 8 (40%) had HAE. The average hospital stay before diagnosis of CAE and HAE was 0.5 ± 0.9 days and 17.4 ± 8.9 days. Table 1 presents a summary of the clinical characteristics for both groups. The mean ages of the patients in the CAE and HAE groups were 59.9 ± 16.8 years and 55.9 ± 14.7 years, respectively. The male-to-female ratio in both groups was 3: 1. The HAE patients had a lower pH of arterial blood gas than the CAE patients (p=0.024). Although the HAE patiens had a lower PaO2 value than the CAE patients, the difference was not statistically significant (p=0.055). The remaining characteristics of the 2 groups, including clinical signs, hemograms, and biochemistry data,

Table 1. Patient Characteristics

Parameters	CAE (n=12)	HAE (n=8)	*p* value
Gender (M:F)	9:3	6:2	
Age (years)	59.9 ± 16.8	55.9 ± 14.7	0.591
Clinical signs (initial presentations)			
Body temperature (°C)	37.0 ± 0.9	36.9 ± 1.2	0.771
Conscious level (Coma scale)	15.0 ± 0.0	15.0 ± 0.0	1.000
Pulse rate (rate/min)	105.8 ± 17.0	120.4 ± 20.1	0.073
Respiratory rate (rate/min)	22.7 ± 4.9	22.3 ± 4.1	0.845
Systolic blood pressure (mmHg)	112.8 ± 36.0	119.1 ± 13.1	0.659
Hemograms			
White blood cell count (10^3/μl)	12.9 ± 12.0	13.7 ± 5.4	0.376
Neutrophil (%)	75.2 ± 25.0	77.8 ± 16.7	0.402
Hematocrit (%)	32.3 ± 4.1	34.7 ± 5.4	0.132
Platelet (10^3/μl)	284.5 ± 128.2	285.1 ± 116.2	0.496
Biochemistry			
Albumin (g/dl)	2.7 ± 0.8	2.6 ± 0.5	0.779
Sugar (mg/dl)	179.2 ± 163.8	192.0 ± 53.8	0.869
Basic urea nitrogen (mg/dl)	30.2 ± 19.7	20.9 ± 10.1	0.239
Serum sodium (mmol/liter)	134.3 ± 5.3	133.6 ± 9.3	0.829
Baseline Arterial blood gas (ABG) analysis			
pH	7.30 ± 0.18	7.47 ± 0.09	0.024
PaO_2 (mmHg)	68.18 ± 18.11	91.44 ± 35.67	0.055
$PaCO_2$ (mmHg)	44.1 ± 27.10	31.3 ± 6.03	0.193
HCO_3^- (meq/L)	20.1 ± 8.17	21.95 ± 5.45	0.346

PaO_2: partial pressure of arterial oxygen; $PaCO_2$: partial pressure of arterial carbon dioxide; HCO_3^-: arterial bicarbonate

Table 2. Underlying Diseases of all Patients in Both Groups

Parameters	CAE (n=12)	HAE (n=8)	*p* value
Malignancy	4 (33.3%)	7 (87.5%)	0.017
Lung cancer	1 (8.3%)	3 (37.5%)	0.110
Buccal cancer	0 (0%)	1 (12.5%)	0.209
Laryngeal cancer	0 (0%)	1 (12.5%)	0.209
Esophageal cancer	0 (0%)	1 (12.5%)	0.209
Hepatocellular carcinoma	0 (0%)	1 (12.5%)	0.209
T-lymphoblastic lymphoma	0 (0%)	1 (12.5%)	0.209
Mesothelioma	1 (8.3%)	0 (0%)	0.402
Malignant hemangiopericytoma	1 (8.3%)	0 (0%)	0.402
Rectal cancer, Duke D	1 (8.3%)	0 (0%)	0.402
Chronic obstructive airway disease	2 (16.7%)	0 (0%)	0.224
Asthma	1 (8.3%)	1 (12.5%)	0.761
Bronchiectasis	1 (8.3%)	0 (0%)	0.402
Diabetes mellitus	3 (25.0%)	1 (12.5%)	0.494
Congestive heart failure	3 (25.0%)	0 (0%)	0.125
Steroid use	2 (16.7%)	2 (25.0%)	0.648

were not statistically different.

Table 2 lists the underlying diseases of both patient groups. Of the 12 CAE patients, 4 (33.3%) had a history of malignancy (3 with progressive cancer and 1 with a history of malignant hemangiopericytoma who was in a disease-free status). Of the 8 HAE patients, 7 (87.5%) had a history of cancer (6 with cancer currently in progression and 1 with lung cancer status following pneumonectomy); the only patient without a history of cancer was diagnosed with hepatocellular carcinoma 27 months after the empyema episode. The prevalence of other comorbidities, including asthma, diabetes mellitus, steroid use (found in both groups) or bronchiectasis and congestive heart failure (found only in patients with community-acquired empyema), were not significantly different between the 2 groups. No patient in this study had a history of cerebrovascular accidents or renal disease.

Of the 11 patients with underlying neoplastic diseases, 2 (18.1%) were disease-free (1 with malignant hemangiopericytoma and lung metastasis status following surgery, radiotherapy and chemotherapy; 1 with lung cancer following pneumonectomy) and 9 had active neoplastic diseases. The mortality rate was 33% in the patients with active neoplastic diseases. The average interval from diagnosis of cancer to culture-proven empyema was 20.25 ± 20.80 months (range, 0.5-53 months). Seven of 9 patients had received chemotherapy. None of these 9 patients had leukopenia when diagnosed with pneumococcal empyema.

Table 3 presents the treatment and clinical outcome of the CAE and HAE patients. After culture-proven empyema was diagnosed, the HAE patients had a longer duration of parenteral antibiotics therapy, duration of fever and duration of hospital stay, than the CAE patients (all $p< 0.05$, respectively). The duration required for closed drainage (either by chest tube or by pig-

tail catheter) was not significantly different between the 2 groups. Three patients with CAE did not receive closed drainage: 1 declined closed drainage and recovered after many instances of chest tapping; 1 died due to rapidly progressing pneumonia with septic shock before closed drainage could be performed, 1 had only a very small amount of empyema and died due to upper gastrointestinal bleeding. One patient with HAE did not receive closed drainage because tumor bleeding developed suddenly after diagnosis of empyema and the patient died. Seven (58.3%) of 12 patients in the CAE groups and 6 (75%) of 8 patients in the HAE groups were transferred to an ICU, and the average hospital stay was 8.3 ± 17.0 days and 15.1 ± 18.3 days, respectively. No patient received intrapleural fibrinolytic agents. Mortality rates during hospitalization were 16.7% (2/12) in the CAE group (1 patient without a history of cancer died due to septic shock and 1 with a history of hemangiopericytoma died due to upper gastrointestinal bleeding), and 37.5% (3/8) in the HAE group (1 with esophageal cancer died due to multiple organ failure, 1 with buccal cancer died due to tumor bleeding, and 1 with triple cancer died due to arrhythmia).

The insusceptible rates for penicillin, cefuroxime, ceftriaxone, and vancomycin were 41.7%, 33.3%, 0%, and 0%, respectively, for the CAE patients (Table 4), and 62.5%, 50%, 12.5%, and 0%, respectively, for the HAE patients (Table 4). In the patients with susceptible and insusceptible isolates to penicillin, cefuroxime and ceftriaxone, the mortality rates were 30% (3/10) and 20% (2/10), 25% (3/12) and 25% (2/8), 21.1% (4/19) and 100% (1/1), respectively (p=0.605, 1.000, and 0.076, respectively).

Discussion

Pneumococcus is a major cause of community-acquired infections, and there is increasing interest in its role in the epidemiology of hospital-acquired infections [10]. Most studies analyzing pneumococcal infections have focused on lung infection, either community-acquired or hospital-acquired pneumonia. This study is the first to highlight the different characteristics and outcomes associated with CAE and HAE caused by pneumococcus. Retrospective analysis of patient data showed that HAE patients had poorer outcomes than CAE patients, leading to longer fever duration, antibiotic use, and subsequent hospital stay for the HAE patients. Underlying malignancy was a major risk factor for HAE. Once patients developed an invasive pneumococcal disease, such as HAE or CAE, antibiotic susceptibility did not influence patient the outcome.

In adults with pneumococcal pneumonia, pleural effusion can occur in up to 57% of cases [11]. Most cases of pleural effusion resolve spontaneously without the need for further intervention. However, because of the interplay of a number of host and microbial factors, pleural effusion can progress to empyema (a collection of purulent material in the pleural space). Pleural empyema is the most common complication of bacterial pneumonia. Examination of pleural fluid parameters helps determine the presence of an empyema and the need for drainage. Pleural empyema in pneumococcal pneumonia has an incidence of 2% to 8% [12]. Unfortunately, there have been no controlled prospective trials with children that compare the outcome of different treatment strategies for empyema.

Fever, tachycardia, tachypnea and leukocytosis commonly present in patients with systemic inflammatory response syndrome. In this study, baseline tachycardia and mild tachypnea were identified in both the CAE and HAE groups; how-

Table 3. Treatment and Clinical Outcome of Patients in Both Groups

Parameters	CAE (n=12)	HAE (n=8)	*p* value
Duration of antibiotics therapy (days)	23.2 ± 10.2	36.8 ± 15.6	0.030
Duration of drainage (days)	16.2 ± 9.8 (n=9)	24.1 ± 16.4 (n=7)	0.248
Duration of fever (days)	8.8 ± 8.6	21.6 ± 14.2	0.022
ICU stay (days)	8.3 ± 17.0 (n=7)	15.1 ± 18.3 (n=6)	0.604
Hospital stay (days)	27.5 ± 14.3	48.0 ± 18.2	0.012
Mortality rate	16.7% (2/12)	37% (3/8)	0.292

Table 4. Insusceptibility to Antibiotics Rate in Both Groups

Antibiotics	CAE	HAE	*p* value
Penicillin	41.6%	62.5%	0.361
Cefuroxime	33.3%	50%	0.456
Ceftriaxone	0%	12.5%	0.209
Vancomycin	0%	0%	-

ever, the mean body temperature on arrival was normal. Lack of fever (>38°C) has been associated with a high in-hospital mortality rate among CAE patients [13]. Therefore, excluding pneumococcal empyema for patients with pneumococcal pneumonia and pleural effusion is important even when the patient is initially afebrile. Similarly, initial arterial blood gas analysis indicated that the HAE patients had a higher pH and PaO2 than the CAE patients (p=0.024 and 0.055, respectively). A review of the chest films showed that 11 (91.7%) of the 12 CAE patients had pneumonic patches, and only 4 (50%) of the 8 HAE patients had pneumonic patches when empyema was identified (p=0.035). Since HAE was not necessarily a complication of pneumonia, the lung parenchyma and airways were minimally involved initially in some cases.

In the CAE group, 2 patients had chronic obstructive pulmonary disease (COPD), 1 had bronchiectasis and 3 had congestive heart failure. In contrast, no patient had COPD, bronchiectasis, or congestive heart failure in the HAE group. This difference in underlying diseases may account for the blood gas data which showed that the CAE group had more severe acidosis and hypoxemia than the HAE group. Despite the better arterial blood gas data, the HAE group had worse outcomes than the CAE group, suggesting that an underlying airway disease and heart function may not be the major determinants of pneumococcal empyema. A further study with a larger number of patients than that in this study is needed to determine the clinical significance.

Outcomes were poor for pneumococcal infection [4] and empyema [14] in patients with major underlying diseases. This study recognized that the prevalence of cancer was higher (87.5%) among the HAE patients than the CAE patients (33.3%) (p=0.017). Several possible reasons may account for the increased susceptibility to empyema of patients with malignant diseases. First, these patients need hospitalization for chemotherapy, radiotherapy and surgery; consequently, they are often exposed to the risk of nosocomial infections. Besides, the primary sites of cancer of the patients in this study were the intrathoracic organs, such as the lungs, esophagus and pleura. Some cases with a primary site outside the thorax had lung metastases. Most of these patients had undergone invasive procedures for intrathoracic lesions. Previous lung surgery is an important risk factor for infection [15-16]. Moreover, an endobronchial lesion is also a predisposing factor for

an empyema. A pre-existing fluid accumulation, either malignant pleural effusion or transudates secondary to hypoalbuminemia or volume reduction, also contributed to bacterial translocation. Bone marrow suppression after chemotherapy was considered an etiology of an immunocompromised status; however, no patient in this study group had leukopenia. Compared with the CAE patients, the HAE patients had a longer duration of fever, period of parenteral antibiotic therapy, and length of hospital stay. Based on this study and the literature [14], we propose that underlying malignancy should be the major precipitating factor for HAE.

The rates of insusceptiblity to penicillin and cefuroxime were higher in this study. Several previous studies had demonstrated that insusceptibility to penicillin is not associated with higher mortality for patients with pneumococcal infections [4]. In this study, no statistically significant difference existed for insusceptibility rates between the CAE and HAP patients, suggesting that antibiotic insusceptibility did not influence patient outcome. This finding is somewhat consistent with those of a previous study of pneumococcal pneumonia [4].

No patients in this study had received a pneumococcus vaccine before the episode of pneumococcal pneumonia. Schultz reviewed 230 pediatric patients hospitalized for empyema, and concluded that after universal use of the pneumococcal conjugate vaccine, the number of patients with empyema and the prevalence of pneumococcus decreased [17]. In an era when vaccines against pneumococcal disease are available, understanding the epidemiology of serious pneumococcal infections is important to planning strategies that prevent invasive diseases and remaining vigilant regarding changes in serotype distribution. The recently licensed 7-valent pneumococcal conjugate vaccine (Prevnar; Wyeth-Lederle Vaccines) recommended for universal use for children <23 months of age does not contain serotype 1 [18]. However, the licensed 23-valent polysaccharide vaccines and the investigational 9-valent and 11-valent pneumococcal conjugate vaccines containing serotype 1 have also been available recently [19]. Since malignant disease is a major risk factor of pneumococcal empyema, vaccines may be considered for patients with cancer, especially those with an intrathoracic origin involvement or lung metastases.

The major limitations of this study are as follows (1). The study used a retrospective design. (2) Culture-negative cases were excluded; only patients with pleural effusion culture-proven pneumococcal empyema were enrolled. However, determining that a patient has pneumococcal empyema in culture-negative cases is difficult. (3) There were too few patients in this series. A prospective, large-scale study is needed to confirm the findings reported herein.

In conclusion, the HAE patients, compared to the CAE patients, had a longer period of fever, and required a longer hospital stay and parenteral administration of antibiotics. Further studies are needed to determine whether the difference in mortality rates between CAE and HAE is statistically significant. Underlying malignancies were a major risk factor for HAE.

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肺炎球菌導致之膿胸在成年病患的臨床特徵及預後

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背景：肺炎球菌是肺炎最重要的致病菌。雖然膿胸是肺炎的常見併發症，目前針對肺炎球菌造成的膿胸的臨床表現及危險因子的討論並不多。

方法：回溯研究在 1998 年 11 月至 2005 年 5 月間，在台北長庚醫院住院 時，肋膜腔積液檢體中培養出肺炎球菌的 20 位成年病患，其基本資料，潛在疾病及對抗生素不敏感的比例。病患被分成社區感染膿胸（n=12）及院內感染膿胸（n=8）兩組，其治療結果亦經比較。

結果：院內感染膿胸的病患，相較於社區感染膿胸的病患，在患病初始，有較快的心搏速率，動脈血有較高的 pH 值及氧氣分壓（分別為 p=0.073 ， 0.024 及 0.055）。惡性腫瘤在兩組都是最重要的危險因子，而在院內感染膿胸的病患更為常見（社區感染 33％，院內感染 87.5％， p=0.017）。惡性腫瘤原發部位以肺及頭頸部為主。院內感染膿胸需使用抗生素的時間較長，發燒及住院時間也較（p<0.05）長。兩組菌株對 penicillin ， cefuroxime ， ceftriaxone 及 vancomycin 的不敏感比例無顯著差別（p>0.2）。

結論：肺炎球菌導致的膿胸病患中，院內感染者有較差的預後。惡性腫瘤是主要的危險因子，在院內感染膿胸者盛行率更高。*(胸腔醫學* ***2006; 21: 413-421)***

關鍵詞：肺炎球菌，膿胸，肋膜，惡性腫瘤，抗生素，敏感性

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