Clinical Characteristics and Therapeutic Outcomes of Postneurosurgical Bacterial Meningitis in Elderly Patients over 65: A Hospital-based Study

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Abstract

Purpose: To investigate the clinical characteristics, laboratory features and prognostic factors of elderly patients with postneurosurgical bacterial meningitis.

Methods: Five hundred and forty patients with adult bacterial meningitis (ABM) were collected from 1986-2015, of whom 167 were ≥ 65 years. Of these 167 elderly patients, 82 had postneurosurgical infections and 85 had spontaneous infections. Clinical, laboratory and therapeutic data of these two groups were compared.

Results: The 82 elderly ABM patients with postneurosurgical infections included 48 men and 34 women with a median age of 71 years (range: 65-84 years). In addition to the postneurosurgical condition, the other most common underlying conditions included diabetes mellitus (29.3%) and hydrocephalus (29.3%). The major clinical presentations were fever (80.5%), altered consciousness (50.0%), hydrocephalus (43.9%), seizure (24.4%) and septic shock (15.9%). Of the implicated pathogens, staphylococcal species (spp.) were the most common (31.7%), followed by *Acinetobacter* spp. (12.2%), *Enterobacter* spp. (7.3%), *Pseudomonas* spp. (7.3%), *Enterococcus faecalis* (7.3%) and *Escherichia coli* (6.1%). The implicated staphylococcal spp. had a high rate of non-susceptibility to methicillin (84.6%), and the implicated *Acinetobacter* spp. and *Enterobacter* spp. had non-susceptible rates to ceftazidime of 60% and 50%, respectively. The mortality rate was 28.1%, and septic shock was the most significant prognostic factor. Compared with the clinical characteristics of the other 85 elderly patients with spontaneous ABM, there were significant differences in underlying condition, clinical and laboratory features and therapeutic outcomes.

Conclusions: Elderly patients accounted for 30.9% of all cases of ABM, of whom 49.1% had postneurosurgical ABM. The clinical characteristics of the elderly patients with postneurosurgical ABM were non-specific, and cerebrospinal fluid studies were needed to confirm the diagnosis. The mortality rate of this group of patients was high, and septic shock was an important prognostic factor. The clinical and laboratory features and therapeutic outcomes were different between the elderly patients with postneurosurgical and spontaneous ABM.

Keywords: bacterial meningitis, elderly, postneurosurgical infection, spontaneous infection, septic shock

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INTRODUCTION

Despite the availability of new therapeutic strategies with regards to the choice of antimicrobial agents and treatment options, adult bacterial meningitis (ABM) remains a potentially fatal infectious disease with the survivors usually experiencing neurological deficits[1-5]. Bacterial meningitis is more common in older patients because of the success of vaccination programs in reducing the risk of major pathogen-related meningitis in young children[3-6], and this situation is becoming increasingly obvious in countries with an increasingly aged population such as Taiwan[7,8], where 13.55% of the population is elderly. Elderly patients are more vulnerable to infectious diseases including bacterial meningitis and tend to have a poor prognosis[8-11]. Furthermore, the classic presentation of acute bacterial meningitis can be obscured in elderly patients, as well as in those ABM patients with a postneurosurgical state as the preceding event[3-5]. Therefore, the aim of this study was to analyze the clinical characteristics and therapeutic outcomes of elderly patients (> 65 years) with ABM in order to examine the epidemiologic trend and therapeutic strategy of this specific group of patients.

METHODS

We retrospectively reviewed the microbiological data of cerebrospinal fluid (CSF), blood cultures, laboratory examinations, medical records and/or surgical condition of adult patients (≥ 17 years) with culture-proven bacterial meningitis admitted to Chang Gung Memorial Hospital (CGMH)-Kaohsiung over a period of 30 years (1986 to 2015). CGMH-Kaohsiung is a 2,550-bed acute-care teaching hospital providing both primary and tertiary care, and it is the largest medical center in southern Taiwan. During the study period, 540 adult patients with culture-proven bacterial meningitis were enrolled, of whom 167 were elderly (≥65 years). Of these 167 elderly patients, 82 had postneurosurgical infections and 85 had spontaneous infections. This study was approved by the Ethics Committee of CGMH-Kaohsiung (IRB No: 201601060B0).

In this study, the criteria for a definite diagnosis of bacterial meningitis were: (1) a positive CSF culture for bacterial pathogen(s); (2) clinical features of meningitis including fever, altered consciousness, seizures, acute hydrocephalus and signs of meningeal irritation; and (3) purulent CSF features, with at least one of the following: pleocytosis with leukocyte count >0.25 × 10^9/l and predominant polymorphonuclear cells, lactate concentration >3.5 mmol/l, glucose ratio (CSF glucose/serum glucose) <0.4 or CSF glucose level <2.5 mmol/l if no simultaneous blood glucose level was determined[1,2]. Because viridans streptococci and coagulase-negative staphylococci (CoNS) are common contaminants of cultures, the diagnosis of meningitis caused by these two groups of pathogens was defined by stricter criteria as only if repeated CSF cultures demonstrated positive results or if they were cultured from the tip of an indwelling neurosurgical device.

In this study, the patients were considered to have "mixed bacterial meningitis" if at least two bacterial organisms were isolated from the initial CSF culture [2,12]. The patients who developed meningitis related to head trauma with skull fractures or neurosurgical procedures were classified as having "postneurosurgical" meningitis, otherwise, the patients who demonstrated no clear distinctive disease characteristics and who had not undergone any invasive procedures were classified as having "spontaneous" meningitis[1,2]. A "nosocomial" infection was defined as a positive bacterial infection not present when the patient was admitted to the hospital, clinical evidence of an infection no sooner than 48 hours after admission, or clinical evidence of meningitis within a short period of time (usually within 1 month after discharge from the hospital where the patient had received an invasive procedure, especially a neurosurgical procedure)[1,2]. Otherwise, the patients were considered to have a "community-acquired" infection.

The initial consciousness level of the patients with acute bacterial meningitis was classified into two groups: normal consciousness (Glasgow coma scale (GCS) score = 15) and altered consciousness (GCS score <15). "Bacteremia" was defined as multiple blood cultures growing the same bacterial pathogen. During the study period, intravenous vancomycin with a third generation cephalosporin (ceftriaxone, ceftazidime) or cefepime were the initial empiric antibiotics used to treat adult patients with clinical evidence of bacterial meningitis.

Further antibiotic treatment was then adjusted according to the results of pathogen identification and antibiotic susceptibility tests. Antibiotic susceptibility of the isolated pathogen was tested using the Kirby-Bauer diffusion method (BBL, Muller-Hinton II agars; Becton Dickinson Microbiology Systems, Cockeyville, MD, USA). Other antibiotics used after the final bacterial culture and antibiotic susceptibility test results had been obtained included oxacillin, linezolid, metronidazole and meropenem.

For statistical analysis, the enrolled elderly patients with postneurosurgical ABM were divided into two groups; survivors and non-survivors. Data including sex, type of infection, underlying conditions, clinical manifestations, and therapeutic outcomes between these two groups were analyzed using the χ^2 test. Differences in age between the two groups and CSF data were analyzed using the Student's t-test, and consciousness levels at the time of admission were compared using the Mann-Whitney test. Relationships among variables and the two patient groups were analyzed using multiple logistic regression analysis adjusted for other potential confounding factors. Variables with zero cell counts were eliminated from the logistic analysis, and only variables with statistical significance ($p < 0.05$) were included in the final model. All analyses were conducted using SSPS software version 20.0.

RESULTS

Of the 82 elderly patients with postneurosurgical ABM, 48 were men and 34 were women, with a median age of 71 years (range: 65-84 years) (Table 1 and Figure 1). Table 1 also lists the other clinical characteristics and laboratory findings of these 82 patients. Besides the existing postneurosurgical conditions, the other common underlying conditions of these 82 patients included diabetes mellitus (DM) in 24 patients, hydrocephalus in 24, malignancy in seven, and brain tumors in six (Table 2). Fever was the most common clinical presentation in 66 patients, with altered consciousness in 41, hydrocephalus in 36, seizure in 20, and septic shock in 13. The clinical characteristics of the other 85 elderly patients with spontaneous ABM are also listed in Table 1.There were significant differences in the underlying conditions (presence of hydrocephalus, liver cirrhosis and brain tumors), clinical presentations (altered consciousness, hydrocephalus, seizure, bacteremia, brain abscess), CSF profiles (levels of total protein, lactate and white blood cell count) and therapeutic outcomes between the postneurosurgical and spontaneous groups (Table 1).

The causative bacterial pathogens of the postneurosurgical group are listed in Table 3. Seventy-seven of these 82 patients had a monomicrobial infection, and the other five had mixed infections. Of the 77 patients with a monomicrobial infection, 40 had a Gram-negative (G(-)) pathogen infection, and the other 37 had a G(+) pathogen infection. Of the implicated pathogens, staphylococcal species (spp.) were the most common, found in 26 of the patients (11 with *Staphylococcus aureus* infection and 15 with CoNS infection). The other most common implicated G(+) pathogen was *Enterococcus faecalis*, found in six patients. Of the implicated G(-) pathogens, *Acinetobacter* spp. were the most common (10), followed by *Enterobacter* spp. (6), *Pseudomonas* spp. (6), and *Escherichia coli* (5).The implicated pathogens of the five patients with mixed infections included 10 bacterial strains: *Acinetobacter* spp. (2), *Pseudomonas aeruginosa* (2), *Enterococcus faecalis* (1), *Citrobacter diversus* (1), *Bacteroide fragilis* (1), *Escherichia coli* (1), *Klebsiella pneumoniae* (1), and *β-streptococcus* group D (1).The implicated bacterial pathogens of the other 85 patients with spontaneous ABM are also listed in Table 3, in which the implicated pathogens of the five patients with mixed infections were *Pseudomonas* spp. (2), viridans streptococci (2), *Staphylococcus aureus* (1), *Acinetobacter spp*. (1), *Staphylococcus caprae* (1), *β-streptococcus group B* (1), *Aeromonas caviae* (1), and *Peptostreptococcus micros* (1).

The results of antimicrobial susceptibility testing of the common implicated pathogens of the elderly patients with postneurosurgical ABM are listed in Table 4. Of the implicated G(-) strains, 60% (6 strains) of the *Acinetobacter* spp. and 50% (3 strains) of the *Enterobacter* spp. were non-susceptible to ceftazidime, while all of the strains of *Acinetobacter* spp., *Pseudomonas* spp., *Enterobacter* spp. and *Escherichia coli* were susceptible to meropenem. With regards to the implicated G(+) strains, 90% (10 strains) of the *Staphylococcus aureus* and 80% (12 strains) of the CoNS were not susceptible to methicillin,

Table 1. The clinical characteristics and laboratory features of the 167 elderly patients with acute bacterial meningitis

	Spontaneous n=85 (%)	Post-NS n=82 (%)	OR	*p* value
Age (years); median (range)	71 (65-88)	71 (65-84)		0.221
Gender				
Male	44	48	1.163	0.379
Female	41	34		
Underlying conditions				
Diabetes mellitus	37 (43.5)	24 (29.3)	1.487	0.056
Hydrocephalus	4 (4.7)	24 (29.3)	0.161	<0.001
Malignancy	9 (10.6)	7 (8.5)	1.378	0.490
Liver cirrhosis	12 (14.1)	3 (3.7)	3.859	0.018
End-stage renal disease	8 (9.4)	2 (2.4)	3.859	0.058
Brain tumor	1 (1.2)	6 (7.3)	0.161	0.048
Drug abuse	0 (0.0)	1 (1.2)	1.012	0.307
Systemic lupus erythematosus	0 (0.0)	1 (1.2)	1.012	0.307
Clinical presentations				
Fever	72 (84.7)	66 (80.5)	1.052	0.472
Altered consciousness	71 (83.5)	41 (50.0)	1.398	0.001
Hydrocephalus	18 (21.2)	36 (43.9)	0.482	0.002
Seizure	33 (38.8)	20 (24.4)	1.592	0.045
Septic shock	19 (22.4)	13 (15.9)	1.410	0.286
Bacteremia	47 (55.3)	7 (8.5)	6.477	<0.001
Brain abscess	12 (14.1)	4 (4.9)	2.894	0.043
Hyponatremia	7 (8.2)	5 (6.1)	1.351	0.593
HHS or DKA	6 (7.1)	2 (2.4)	2.894	0.162
Subdural empyema	2 (2.4)	5 (6.1)	0.386	0.227
Cerebrospinal fluid leakage	0 (0.0)	3 (3.7)	1.308	0.075
Cerebrospinal fluid				
Glucose (mmol/L)	2.67±50.38	3.06±38.04		0.590
Total protein (g/L)	4.91±398.17	2.05±260.35		<0.001
Lactate (mmol/L)	13.45±71.82	8.74±64.04		<0.001
White blood cell count (109/L)	8.19±30153.76	1.08±2500.63		0.046
Prognosis				
Survived	47 (55.3)	59 (71.9)	1.0594	0.025
Expired	38 (44.7)	23 (28.1)		

Post-NS: post-neurosurgical; HHS: hyperosmolar hyperglycemic status; DKA: diabetic ketoacidosis

However all of the staphylococcal spp. and Enterococcus spp. were susceptible to vancomycin. After treatment, 23 of the 82 patients with postneurosurgical ABM died, for a mortality rate of 28.1%. The significant prognostic factors included altered consciousness, septic shock and brain tumors (Table 5). In logistic regression analysis, only the presence of septic shock was independently associated with the prognosis.

DISCUSSION

Old-age is an important poor prognostic factor in patients with infectious diseases, including bacterial meningitis[1,2,13,14]. In this study, elderly patients (≥ 65 years) accounted for 30.9% (167/540) of all cases of ABM. Of these 167 elderly patients, 70 (41.9%) were aged from 65-69 years, and 14 (8.4%) were aged >80 years (Figure 1). Because of the increasingly elderly population, the relative frequency of patients with ABM in Taiwan can be expected to increase, thereby having an impact on medical burden and causing a therapeutic challenge[8]. Among the 167 elderly patients with ABM in the current study, 85 (50.9%) had spontaneous infections and 82 (49.1%) had postneurosurgical infections. Although many clinical characteristics significantly differed between the two groups (Table 1), they were neither specific nor unique. Therefore, a high suspicion of the existence of bacterial meningitis in this specific group of postneurosurgical elderly patients is important for the diagnosis, and further CSF studies including cultures are important to confirm the diagnosis.

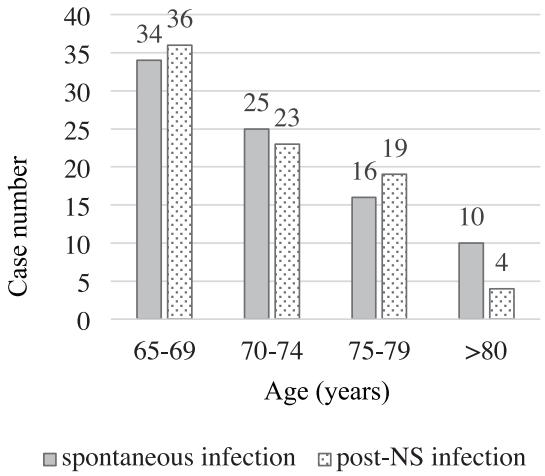

Figure 1. The age distribution of the 167 elderly patients with acute bacterial meningitis.

Although the number of implicated G(-) and G(+) pathogens was almost the same in both spontaneous and postneurosurgical groups, the composition of the implicated pathogens was quite different (Table 3). The main implicated bacterial pathogens in the postneurosurgical group were *Staphylococcus* spp., *Acinetobacter* spp., *Enterobacter* spp., *Pseudomonas* spp. and *Enterococcus faecalis*, all of which are common bacterial pathogens in postneurosurgical bacterial meningitis in adults[2,15-19], and except for *Pseudomonas* spp., these pathogens were uncommon in the spontaneous ABM group. *Klebsiella pneumoniae* is a common bacterial pathogen in ABM in Taiwan, and it is usually seen in

Table 2. Neurosurgical conditions of the 82 elderly patients with post-neurosurgical bacterial meningitis

Post-neurosurgical condition	Number of cases
s/p Ventricular-peritoneal shunt	40
s/p Extraventricular drainage	33
Intracerebral hemorrhage s/p removal of hematoma	21
s/p Craniotomy	19
s/p Craniectomy	11
Aneurysm s/p clipping	7
Brain tumor s/p removal of tumor	5
s/p Cranioplasty	5
s/p Ventriculostomy	4
s/p Laminectomy	4
s/p Omaya placement	2
Others*	7

*One patient may have had ≥ 1 neurosurgical condition; others = subduro-peritoneal shunt (1); corticectomy (1); removal of ventriculoperitoneal shunt and debridement of an abdominal wound (1); brain tumor biopsy (1); debridement of sphenoid sinus (1); placement of intracerebral pressure monitor (1); Pneumocranium (1)

Table 3. The causative pathogens of the 167 elderly patients with acute bacterial meningitis

Pathogen	Spontaneous (n=85)	Post-neurosurgical (n=82)
Monomicrobial infection	80	77
Gram-negative pathogen	39	40
Klebsiella pneumoniae	25	4
Acinetobacter species	1	10
Acinetobacter baumannii	1	7
Acinetobacter junnii	0	1
Acinetobacter lwoffi	0	2
Enterobacter species	0	6
Enterobacter aerogenes	0	3
Enterobacter cloacae	0	3
Pseudomonas species	4	6
Pseudomonas aeruginosa	3	5
Pseudomonas mendocina	0	1
Pseudomonas stutzeri	1	0
Escherichia coli	5	5
Proteus mirabilis	2	1
Salmonella enterica	2	1
Salmonella enterica serogroup B	2	0
Salmonella enterica serogroup D	0	1
Citrobacter diversus	0	2
Serratia marcescenes	0	1
Alcaligenes xylosoxidans	0	1
Ralstonia insidiosa	0	1
Morganella morganii	0	1
Chryseobacterium meningosepticum	0	1
Gram-positive pathogen	41	37
Staphylococcus aures	8	11
Coagulase-negative Staphylococci	2	15
Staphylococcus epidermidis	0	9
Staphylococcus haemolytics	0	1
Staphylococcus capitis	0	1
Staphylococcus saprophyticus	2	1
Staphylococcus hominis	0	1
Non-classified Coagulase-negative Staphylococci	0	2
Streptococcus pneumoniae	10	0
β-streptococcus group A	2	1
β-streptococcus group D	1	0
Non-A, B, D streptococcus	1	0
Viridans streptococci	11	0
Listeria monocytogenes	5	0
Enterococcus faecalis	2	6
Nocardia species	0	1
Corynebacterium	0	1
Propionibacterium acnes	0	1
Bacillus	0	1
Mixed infections	5	5

patients with community-acquired spontaneous infections, especially in those with DM and/or cirrhosis[20-22]. Because of long life expectancy and changes in lifestyle, both DM and liver disease with cirrhosis are common in Taiwan with an increasing incidence, and they are more frequently seen in elderly patients[9,22-25]. In this study, DM (43.5%, 37/85) and cirrhosis (14.1%, 12/85) were common underlying conditions of the elderly patients with spontaneous ABM (Table 1), and this may explain the relatively high incidence of *Klebsiella pneumoniae* infection in this group but not in the postneurosurgical group, although 29.3% (24/82) of this group also had DM.

Staphylococcal spp. infections, especially CoNS infections, in ABM are usually seen in patients with a postneurosurgical state as the preceding event[2,18,19,26]. This epidemiologic trend was also found in the current study (Table 3), in which staphylococcal spp. were found in 31.7% (26/82) and 11.8% (10/85) of the postneurosurgical and spontaneous groups, respectively. In the spontaneous group, the other common implicated G(+) strains were *Streptococcal pneumoniae* and viridans streptococci, both of which are usually seen in community-acquired spontaneous ABM[2,27,28]. In this study, *Streptococcus pneumoniae* infection was not found in the postneurosurgical group, and its incidence was also low (11.8%, 10/85) in the spontaneous group. This relatively low incidence may be related to the introduction of a pneumococcal vaccination in Taiwan since 2005[29], which is known to have played an important role in preventing invasive pneumococcal infections.

Of the common implicated pathogens in the postneurosurgical group, a high incidence of G(-) strains

Table 4. Antibiotic susceptibility tests of the common implicated pathogens in the elderly patients with post-neurosurgical bacterial meningitis

Gram-negative pathogens						
	Susceptibility test					
	Ceftriaxone		Ceftazidime		Meropenem	
	Susceptible	Non-susceptible	Susceptible	Non-susceptible	Susceptible	Non-susceptible
Acinetobacter species n=10 (%)	–	–	4 (40.0)	6 (60.0)	10 (100.0)	0 (0.0)
Pseudomonas species n=6 (%)	–	–	6 (100.0)	0 (0.0)	6 (100.0)	0 (0.0)
Enterobacter species n=6 (%)	3 (50.0)	3 (50.0)	3 (50.0)	3 (50.0)	6 (100.0)	0 (0.0)
Escherichia coli n=5 (%)	5 (100.0)	0 (0.0)	5 (100.0)	0 (0.0)	5 (100.0)	0 (0.0)
Gram-positive pathogens						
	Susceptibility test					
	Penicillin		Oxacillin		Vancomycin	
	Susceptible	Non-susceptible	Susceptible	Non-susceptible	Susceptible	Non-susceptible
Staphylococcus aureus n=11 (%)	0 (0.0)	11 (100.0)	1 (9.1)	10 (90.9)	11 (100.0)	0 (0.0)
Coagulase-negative staphylococci n=15 (%)	0 (0.0)	15 (100.0)	3 (20.0)	12 (80.0)	15 (100.0)	0 (0.0)
	Oxacillin		Ampicillin		Vancomycin	
	Susceptible	Non-susceptible	Susceptible	Non-susceptible	Susceptible	Non-susceptible
Enterococcus species n=6 (%)	–	–	4 (66.7)	2 (33.3)	6 (100.0)	0 (0.0)

Table 5. Prognostic factors of the 82 elderly patients with post-neurosurgical bacterial meningitis

	Non-survivors (n=23)	Survivors (n=59)	OR	95% CI	*p* value
Age at meningitis (years)	71.09±4.92	71.25±4.66			0.889
Gender					
Female	11	23	0.855	0.550-1.329	0.465
Male	12	36			
Clinical feature					
Fever	17	49	0.890	0.680-1.164	0.348
Altered consciousness	18	31	1.489	1.077-2.060	0.033
Hydrocephalus	11	25	1.129	0.671-1.899	0.655
Seizure	8	12	1.710	0.805-3.634	0.171
Septic shock	10	3	8.551	2.583-28.301	<0.01
Hyponatremia	0	5	1.093	0.011-1.181	0.150
Subdural empyema	3	2	3.848	0.687-21.555	0.101
Brain abscess	2	2	2.565	0.384-17.148	0.316
CSF leakage	0	3	1.054	0.993-1.118	0.271
DKA / HHS	0	2	1.035	0.987-1.086	0.371
Bacteremia	4	3	3.420	0.829-14.112	0.073
Acquisition of infection					
Community-acquired	7	17	0.977	0.713-1.339	0.855
Nosocomial acquired	16	42			
Initial antimicrobial therapy					
Appropriate	15	47	1.710	0.805-3.634	0.171
Inappropriate	8	12			
Underlying disease					
Diabetes mellitus	6	18	0.855	0.389-1.881	0.693
Previous hydrocephalus	6	188	0.855	0.389-1.881	0.693
Malignancy	3	4	1.924	0.466-7.938	0.362
Brain tumor	4	2	5.130	1.008-26.121	0.029
Liver cirrhosis	2	1	5.130	0.488-53.882	0.129
End-stage renal disease	1	1	2.565	0.167-39.317	0.484
Drug abuser	1	0	0.957	0.877-1.044	0.107
Systemic lupus erythematosus	1	0	0.957	0.877-1.044	0.107
Initial CSF data					
Glucose (mmol/L)	2.58±36.32	3.27±38.61			0.275
Total protein (g/L)	2.69±248.12	1.76±261.31			0.209
Lactate (mmol/L)	11.22±80.91	7.63±53.29			0.234
White count (109/L)	1.20±2506.79	1.04±2526.81			0.642

DKA: diabetic ketoacidosis; HHS: hyperosmolar hyperglycemic state; CSF: cerebrospinal fluid

of *Acinetobacter* and *Enterobacter* spp. that were not susceptible to cephalosporin were found, although they were all susceptible to meropenem (Table 4). For the implicated G(+) pathogens, staphylococcal spp. had a high incidence of methicillin resistance (84.6%, 22/26), and *Enterococcus* spp. had a 33.3% (2/6) resistance rate to ampicillin. Nevertheless, all of the implicated staphylococcal and Enterococcus spp. were susceptible to vancomycin. The presence of anaerobic strains (*Bacteroide fragilis, Peptostreptococcus micros*) in the patients with mixed infections in both groups has important implications for the choice of antibiotics[2]. In this study, the overall mortality rate of the elderly patients with postneurosurgical ABM was 28.1% (23/82), and the presence of septic shock was a significant prognostic factor, which is consistent with previous studies[1,2]. However, the mortality rate was lower compared with the spontaneous group (44.7%, 38/85). This difference may be related to the following clinical characteristics of the spontaneous group: 1) high incidence of underlying medical conditions such as DM, liver and renal disease; and 2) a more fulminant clinical course with a higher incidence of unfavorable presentations such as altered consciousness, hydrocephalus, seizure, bacteremia and brain abscess. Nevertheless, the overall mortality rate (36.5%, 61/167) of elderly patients with ABM was high.

CONCLUSIONS

In this study, elderly patients accounted for 30.9% of all cases of ABM, of whom 49.1% had postneurosurgical infections. Fever and altered consciousness were the main clinical presentations of the patients with postneurosurgical ABM, however these clinical characteristics were neither specific nor unique, and further CSF studies were needed to confirm the diagnosis. The most common implicated bacterial pathogens of this specific group of ABM patients had a high incidence of antibiotic resistance. The overall mortality rate of the elderly patients with postneurosurgical ABM was 28.1%. There were differences in the common implicated pathogens, underlying conditions, clinical presentations, CSF features and therapeutic outcomes between the elderly patients with spontaneous and postneurosurgical ABM. Nevertheless, the therapeutic outcomes of both groups were poor.

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