

STREPTOCOCCUS SUIS MENINGITIS IN THAILAND

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Abstract. *Streptococcus suis* may be the second most common cause of adult streptococcal meningitis. The clinical and epidemiological data of *S. suis* meningitis are occasionally reviewed. To date, there have been only two large case series from Hong Kong and the Netherlands. We describe twelve cases of *S. suis* meningitis who were admitted to Chulalongkorn University Hospital, Bangkok, during a 6-year period between 1997 and 2002. A comparative review of case reports of *S. suis* meningitis in Thailand, Hong Kong, and the Netherlands is presented and revealed no significant differences between the three series. However, the cases from Thailand and Hong Kong had a significantly greater number of associated skin and soft tissue infections. Clinically, *S. suis* meningitis may appear acute or with a more chronic course.

INTRODUCTION

Streptococcal meningitis in humans is most commonly caused by *Streptococcus pneumoniae* in adults, and by *S. agalactiae* in neonates. *S. suis* may be the next most common cause of adult streptococcal meningitis (Zanen and Engel, 1975; Luticken *et al*, 1986; Arends and Zanen, 1988; Arend *et al*, 1995; Kay *et al*, 1995). It is a gram-positive alpha- or gamma-hemolytic *Streptococcus*, and is present as a commensal in the tonsils of pigs (Williams *et al*, 1993). On the basis of serological differences, it is further categorized into two serotypes: serotype 1 (previously named group S) and serotype 2 (previously named group R). Human infections are always caused by *S. suis* serotype 2. Most are observed in adults without preexisting diseases, and are associated with exposure to pigs or raw pork. Most patients are pig breeders or abattoir workers. Thus, many reports originated from countries where pig raising and pork processing are of great importance. It is considered an industrial disease (Dupas *et al*, 1992).

In this report, we describe twelve cases of *S.*

suis meningitis who were admitted to Chulalongkorn University Hospital, Bangkok, during a 6-year period between 1997 and 2002. The clinical and epidemiological data of case reports of *S. suis* meningitis from Thailand, Hong Kong, (Kay *et al*, 1995) and the Netherlands (Arends and Zanen, 1988) are also compared.

MATERIALS AND METHODS

All *S. suis* isolates were collected at the National Streptococcal Reference Center, Department of Microbiology, Chulalongkorn University from January 1, 1997 to May 31, 2002. Clinical and laboratory information was reviewed. All alpha- and gamma-hemolytic Streptococcal colonies on sheep blood agar from clinical specimens were identified as *S. suis* by API-20 STREP system (API-20 Biomerieux, Sa, France). The specific serotype was further characterized with antisera to *S. suis* type 1 and type 2. An antibiotic susceptibility test was performed on all isolates using the Kirby-Bauer method. The minimal inhibitory concentration (MIC) of penicillin and cefotaxime against five isolates were also identified by epsilometer test (E test).

RESULTS

Patient characteristics

Table 1 summarized the characteristics of twelve cases of *S. suis* meningitis from Chula-

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Table 1
Clinical features and epidemiological data for 12 cases of *Streptococcus suis* meningitis from Chulalongkorn University Hospital.

Patient, year	1. 1997	2. 1997	3. 1998	4. 1999	5. 2001	6. 2001
Age (years), Sex	73, M	75, M	43, M	44, M	43, M	52, F
Occupation	Retired	Laborer	Laborer	Laborer	Laborer	Laborer
Underlying disease	CA bladder post cystectomy	Old stroke	Rheumatic heart disease	Steroid abuse, otitis media	No	No
Pig exposure	NA	NA	NA	+ (1 can of beer/day)	NA	NA
Alcohol consumption (quantity)	NA	+(unknown)	+(occasion)		+ (1 quarter/day)	+(unknown)
Days of illness prior to admission	2	1	7	7	7	3
Other complications	No	Sepsis, seizure	No	No	No	Severe low back pain + (deafness, 2 days)
Hearing loss vertigo or nystagmus (onset after illness)	NA	NA	NA	NA	+ (deafness, 8 days)	
CBC						
WBC (cells/ μ l)	9,520	5,590	13,000	17,300	14,800	11,600
PMN (%)	70	84	85	92	80	88
Platelet (cells/ μ l)	515,000	22,900	170,000	351,000	77,000	268,000
CSF						
OP (cmH ₂ O)	21	37	NA	30	NA	33
WBC (cells/ μ l)	8,200	1,150	350	925	1,400	390
PMN (%)	80	90	95	20	74	85
Sugar (mg/dl)	3	21	48	54	2	1
Protein (mg/dl)	NA	290	105	209	193	176
Gram stain	Yes	No	No	No	No	No
Treatment						
Defervescence after treatment (days)	7	14	14	6	6	7
Duration (days)	14	16	15	-	21	12
Outcome	Survived	Survived	Survived	Survived initial treatment as tuberculous meningitis	Survived	Survived

M: male, F: female, CSF: cerebrospinal fluid, OP: opening pressure (mmH₂O), WBC: white blood cells (cells/ μ l), PMN: polymorphonuclear cells, NA: not applicable

longkorn University Hospital. There were nine males and three females with median and mean ages of 45.5 and 49.5 years, respectively (range, 25-75 years).

Predisposing factors

The majority (8, 66.6%) of cases occurred in patients without underlying disease (Table 1). Underlying illnesses included urinary bladder cancer (1, 8.3%), rheumatic heart disease (1,

8.3%), previous cerebrovascular accident (CVA) (1, 8.3%) and chronic arterial insufficiency (1, 8.3%). There were two patients on corticosteroid treatment and 9 patients (75%) with significant alcohol consumption, ranging from occasional to heavy drinking.

Four patients (33.3%) had known histories of contact with pigs or pork meat (Table 1). Of these, three patients had occupational exposures

Table 1
Clinical features and epidemiological data for 12 cases of *Streptococcus suis* meningitis from Chulalongkorn University Hospital (continued).

Patient, year	7. 2001	8. 2002	9. 2002	10. 2002	11. 2002	12. 2002
Age (years), Sex	27, M	39, M	47, F	51, M	29, M	71, F
Occupation	Butcher	Policeman	Butcher	Laborer	Butcher	Housewife
Underlying disease	Steroid abuse	No	No	No	No	Chronic arterial insufficiency of both legs
Pig exposure	+	+	+	NA	+	NA
Alcohol consumption (quantity)	+(unknown)	-	+(half bottle/day)	+(half bottle/day)	+(unknown)	-
Days of illness prior to admission	2	5	10	2	7	1
Other complications	No	Tendinitis of left thigh Severe myalgia of both thighs	Severe myalgia of right leg	Sepsis	Arthritis Cellulitis Fasciitis Cerebritis/ventriculitis	Severe low back pain
Hearing loss vertigo or nystagmus (onset after illness)	+(deafness, 1 day)	+(SNHL, NA)	+(SNHL, 14 days)	+(nystagmus, 2 days)	+(deafness, 7 days)	NA
CBC						
WBC (cells/ μ l)	13,000	16,400	20,600	14,700	31,550	16,870
PMN (%)	90	82	95	95	92	87
Platelet (cells/ μ l)	282,000	313,000	284,000	61,000	369,000	185,000
CSF						
OP (cmH ₂ O)	NA	30	42	NA	21	-
WBC (cells/ μ l)	1,250	1,380	21,800	0	834	540
PMN (%)	20	30	99	0	20	98
Sugar (mg/dl)	53	67	7	26	20	5
Protein (mg/dl)	151	98	75	-	252	171
Gram stain	No	No	Yes	No	No	Yes
Treatment						
Defervescence after treatment (days)	2	2	4	NA	3	3
Duration (days)	30	14	16	NA	14	14
Outcome	Survived	Survived	Survived Relapse 1 day after discontinuation of initial treatment (for 8 days), and then retreatment for another 8 days	Died 18 days after admission	Survived	Survived

M: male, F: female, CSF: cerebrospinal fluid, OP: opening pressure (mmH₂O), Wbc: white blood cells (cells/ μ l), PMN: polymorphonuclear cells, NA: not applicable

(butcher, 3) and one was a policeman who had weekly exposures to raw pork.

Clinical presentations

The median interval from the onset of symptoms to admission was 4 days (range, 1-10 days) (Table 1). Clinical presentations included isolated meningitis (5, 41.7%), meningitis with extra-neurological manifestations (5, 41.7%), and sep-

sis (2, 16.7%) (Table 2). Of 10 meningitic patients, 8 (80%) presented with classic symptoms of meningitis (headache, fever, and nuchal rigidity) with a median duration of 6 days (range, 1-10 days). The neurological complications included deafness (4, 33.3%), subclinical sensorineural hearing loss (demonstrated by audiometry) (2, 16.7%), vestibular dysfunction (1, 8.3%), and cerebritis/ventriculitis (1, 8.3%). The associated

Table 2
Clinical features for 12 cases for *S. suis* meningitis from Chulalongkorn University Hospital.

Diagnosis	Number of patients (%)	Days of illness before admission (median, range)	Fatal outcome
Meningitis	10 (83.3%)	6, 1-10 days	0
Without extraneurological manifestations	5 (41.7%)	7, 2-7 days	0
With extraneurological manifestations	5 (41.7%)	5, 1-10 days	0
Myalgia	5 (41.7%)		0
Arthritis/arthralgia	2 (16.7%)		0
Sepsis	2 (16.7%)	1.5, 1-2 days	1 (50%)

Table 3
Cerebrospinal fluid (CSF) analysis for 12 cases of *S. suis* meningitis from Chulalongkorn University Hospital^a.

Open CSF pressure (cmH ₂ O)	WBC count (cells/ μ l)	PMN (percent)	Sugar levels (mg/dl)	Protein levels (mg/dl)
30, 21-42, 7	1,037, 0-21,800, 12	77, 0-99, 12	20.5, 1-67, 12	173.5, 75-290, 10

^aThe 3 values in each parameter represent median, range, and numbers of tested samples.

extraneurological manifestations included severe myalgia (5, 41.7%), and arthritis (2, 16.7%).

Of the two patients with sepsis, one had associated alcoholic necrotizing pancreatitis and developed seizures, the other had alcoholism and an old CVA, and developed fever and unconsciousness a few hours prior to admission.

Laboratory

Complete blood counts (CBC) showed leukocytosis (median, 14,750 cells/ μ l; range, 5,590-31,500 cells/ μ l; N, 12) with increased polymorphonuclear cells (median, 87.5%; range, 70-95%; N, 12) and a median platelet count of 275,000 cells/ μ l (range, 22,900-515,000 cells/ μ l; N, 12).

Cerebrospinal fluid (CSF) analysis showed high opening pressures (more than 20 cmH₂O) (median, 30 cmH₂O; range, 21-42 cmH₂O; N, 7), pleocytosis (median, 1,037 cells/ μ l; range, 0-21,800 cells/ μ l; N, 12), increased polymorphonuclear cells (median, 77%; range, 0-99%; N, 12), decreased sugar levels (median, 20.5 mg/dl; range, 1-67 mg/dl; N, 12) and increased protein levels (median, 173.5 mg/dl; range, 75-290 mg/dl; N, 10) (Table 3). Gram-positive cocci were demonstrated in the CSF in only 3 patients (25%).

Microbiological cultures

S. suis were grown from the CSF in 8

(66.7%), from blood in 6 (50%), and from both CSF and blood in 3 (25%) patients. All the isolates were *S. suis* serotype 2, and were susceptible to penicillin and third-generation cephalosporins (Table 4). The MIC for penicillin and cefotaxime were determined in 5 isolates. The median MIC for penicillin and cefotaxime was 0.032 and 0.064 μ g/ml (range, 0.025-0.064 μ g/ml and 0.064-0.125 μ g/ml, respectively).

Clinical course

Only 1 patient (8.3%), who had sepsis, died due to uncontrolled infection and necrotizing pancreatitis (Tables 1, 2 and 4). All meningitic patients survived. Of the 11 survivors, the median duration until defervescence was 6 days (range, 2-14 days) after the initiation of penicillin or third-generation cephalosporin therapy. The median and range of the duration of treatment were 14.5 and 12-30 days, respectively. Relapse of infection was observed in one patient during a follow-up period of 8 days. There was complete eradication of infection after retreatment with the same antibiotic for another 8 days. All meningitic patients with deafness retained it permanently.

The summary for the 12 patients with *S. suis* meningitis from Chulalongkorn University Hospital is shown in Table 4.

Table 4
Summary of 12 cases of *S. suis* meningitis from Chulalongkorn University Hospital.

Total cases	12
M:F	9:3
Age (median±SD, mean, range)	45.5±16, 49.5, 27-75 years
Occupation	Laborer: 6 (50%) Butcher: 3 (25%) Policeman: 1 (8.3%) Others: 2 (16.7%)
Underlying disease	4 (33.3%)
Pig exposure	5 (41.7%)
Alcohol consumption	9 (75%)
Days of illness before admission (median, range)	4±3, 4.5, 1-10 days
Skin and soft tissue infections (%)	8 (66.7%)
Shock	2 (16.7%)
Hearing loss or other CN VIII abnormalities (%)	7 (58.3%)
CBC (median±SD, mean, range)	
WBC (cells/μl)	14,750±6,356.8, 15,349.8, 5,590-31,500
PMN (%)	87.5±7.2, 86.7, 70-95
Platelet (cells/μl)	275,000±140,142.7, 236,491.7, 22,900-515,000
CSF (median±SD, mean, range)	
OP (cmH ₂ O) (N, 7)	30±7.8, 30.6, 21-42
WBC (cells/μl)	1,037.5±6,249.5, 3,184.9, 0-21,800
PMN (%)	77±37.7, 59.3, 0-99
Sugar (mg/dl)	20.5±23.9, 25.6, 1-67
Protein (mg/dl) (N, 10)	173.5±68.3, 172, 75-290
Gram stain	3 (25%)
Penicillin sensitivity (N, 5)	12 (100%)
MIC of penicillin (median±SD, range)	0.032±0.016, 0.025-0.064
MIC of cefotaxime (median±SD, range)	0.064±0.033, 0.064-0.125
Treatment (median±SD, mean, range)	
Duration (N, 10)	14.5±6.7, 18, 12-30 days
Days of defervescence after treatment	6±4.3, 6.2, 2-14 days
Mortality	1 (8.3%)

Data are calculated based on a total number of 12 patients, unless otherwise indicated in parentheses.

DISCUSSION

There is wide clinical variation in the presentation of *S. suis* infection in humans, including meningitis, primary bacteremia, arthritis, endocarditis, and pneumonia. Meningitis is the most common clinical manifestation. Human infection was first described in Denmark in 1968. Since then, over 100 cases have been recorded from Europe, North America, East and Southeast Asia. The first two cases in Thailand were reported from Ramathibodi Hospital in Bangkok in 1987 (Phuapradit *et al*, 1987). Twelve cases of *S. suis* meningitis were identified in the 6-year period between 1997 and 2002. Cases 1, 2 and 3 have been published previously (Vilaichone *et al*,

2002). The median age and the age range were 45.5 and 27-75 years, respectively (Table 4). The male-to-female ratio was 3:1. These results are consistent with other reports.

Nine of twelve patients (75%) had occupational contact with pigs or pork (6 laborers and 3 butchers). Four of twelve patients (33.3%) had a definite history of pig exposure. The association between human infection and pig exposure has been well noted since the early description of this disease (Arends and Zanen, 1988; Kay *et al*, 1995; Lutticken *et al*, 1986). The annual risk of developing *S. suis* infection between 1968 and 1984 was calculated to be 3/100,000 among pig breeders and butchers in the Netherlands (Arends and Zanen, 1988).

Table 5
Summary of reported *S. suis* meningitis from Thailand, Hong Kong and the Netherlands.

	Thailand ^a	Hong Kong ^b	Netherlands ^c
Total cases	32	21	30
M:F	23:9	14:7	26:4
Age (median±SD, mean,range)	49±16.7, 50.4, 1 month-75 years	53.7, 20-75	49, 26-76
Occupation	Butcher: 6 Farmer: 3 Laborer: 8 Others: 9	Butcher: 5 Cook: 4 Farmer: 3 Meat transporter: 1 Housewife: 4 Others: 4	Butcher: 14 Pig farmer: 10 Meat transporter: 1 Housewife: 3 Others: 2
Underlying disease	7 (31.8%) (N, 22)	6 (24%) (3 alcoholism, 2 diabetes, 1 tuberculosis)	4 (13%) (2 malignancy, 1 alcohol abuse, 1 Zollinger-Ellison syndrome)
Pig exposure	9 (28.1%) (N, 32)	13 (62%)	27 (9%)
Alcohol consumption	15 (88.2%) (N, 17)	NA (but 3 alcoholism)	NA
Days of illness before admission (mean, range)	4.5, 1-14 days (N, 26)	2.3 days, 8 hours-10 days	2 days, 1-5 days
Skin and soft tissue infections	8 (30.8%) (N, 26)	5 (24%)	1 (3.3%)
Shock (N, 26)	3 (11.5%) (toxic shock syndrome, 1; Sepsis, 2) (N, 26)	NA	NA
Hearing loss or other CN VIII abnormalities	22 (68.8%) (N, 32)	17 (81%) [16 (80%) with hearing loss, 10 (50%) with vertigo], (onset of hearing loss within 1-12 days of admission)	15 (54%) (N, 28)
CBC (median±SD, mean, range)			
WBC (cells/μl)	19,835±10,179, 16,400, 5,590-47,300 (N, 23)	NA	NA
PMN (%)	88±7, 87, 70-96 (N, 16)	NA	NA
Platelet (cells/μl)	268,000±150,362, 224,839, 22,900-515,000 (N, 13)	NA	NA
CSF (median±SD, mean, range)			
OP (cmH ₂ O)	33±10, 31, 14-50 (N, 15)	NA	NA
WBC (cells/μl)	925±4,747, 2,403, 0-21,800 (N, 25)	1,285 ± 2,716, 1,957, 4-10,720 (N, 25)	1,500, 50-110,000 (N, 37)
PMN (%)	65±37, 55, 0-99 (N, 27)	NA	NA
Sugar (mg/dl)	5±20, 16, 0-67 (N, 23)	7.2 ± 24.3, 19.6, 1.8-79.2 (N, 21)	27, 1.8-58.5 (N, 25)
Protein (mg/dl)	176±111, 215, 75-456 (N, 21)	406 ± 253, 418, 60-940 (N, 21)	300, 80-980 (N, 34)
Gram stain	18 (56%) (N, 30)	NA	NA
Penicillin sensitivity	32 (100%) (1 isolate was penicillin-resistant but ampicillin-sensitive) (N, 32)	NA	NA
Treatment (median±SD, mean, range)			
Duration (N, 16)	14±6.4, 17.6, 12-30 days (N, 16)	1-6 weeks (2 relapse after treatment of 2 and 4 weeks)	NA
Days of defervescence after treatment	5±3.7, 5.7, 2-14 days (N, 14)	NA	NA
Mortality (N, 32)	2 (6.3%)	1 (4.8%)	2 (6.7%)

Note: Data are calculated based on a total number of 32, 21, and 30 patients for the Thai, Hong Kong, and Dutch series, respectively, unless otherwise indicated in parentheses.

^aSource of data from Phuapradit *et al*, 1987; Pootong *et al*, 1993; Leelarrasamee *et al*, 1997; Paiboonpol, 1998; Chotmongkol *et al*, 1999; Pumprueng and Pongvarin, 1999; Vilaichone *et al*, 2002.

^bSource of data from Kay *et al*, 1995.

^cSource of data from Arends and Zanen, 1988.

An underlying disease was present in only 4 Thai cases (33.3%). This is consistent with other reports which showed that most patients with *S. suis* meningitis had been healthy (Lutticken *et al*, 1986; Arends and Zanen, 1988; Kay *et al*, 1995). A history of significant alcohol consumption was described in 9 of our patients (75%). This has not been documented in previous reports. There is incomplete data to evaluate an association between the amount of alcohol consumption and risk of developing *S. suis* meningitis. We also do not know the prevalence of alcohol consumption among Thai laborers, but feel that it is not that high.

The median and range of time from onset of symptoms until admission were 4 and 1-10 days, respectively. Patients presented as either acute or subacute meningitis.

Skin and soft tissue infections were present in a significant number (5, 41.7%) of our patients. They included myositis (5, 41.7%) and arthritis (2, 16.7%). The incidence was relatively higher than those of other reports which ranged from 0 to 24% (Lutticken *et al*, 1986; Arends and Zanen, 1988; Kay *et al*, 1995). The reason for this observation may be a difference in the strains of *S. suis* or an underestimation of these complications. These associated complications may be clinical clues of *S. suis* infection in patients presenting with acute meningitis.

Hearing loss and other eighth cranial nerve abnormalities were observed in 7 patients (53.8%). The time of onset of hearing loss varied from 1-14 days. This observation is consistent with other reports (Lutticken *et al*, 1986; Arends and Zanen, 1988; Kay *et al*, 1995). Irreversible hearing loss has been recognized as a characteristic complication of *S. suis* meningitis. It is likely to be due to suppurative labyrinthitis with bacteria directly invading the perilymph (Kay, 1991). Two of our patients (16.7%) without deafness were diagnosed by audiometry, which showed bilateral high tone sensori-neural hearing loss. Thus, some patients with *S. suis* meningitis may have subclinical hearing loss. We suggest audiometry in every surviving patient. Other neurological complications were cerebritis and ventriculitis in one case. They were not reported in previous studies.

Complete blood counts (CBC) showed leu-

kocytosis (median, 14,750 and range, 5,590-31,500 cells/ μ l) and neutrophilia (median, 87.5 and range, 70-95%). This should be a clue to suspect *S. suis* meningitis, particularly when tuberculous meningitis has been excluded. All our patients had neutrophilia, and all except two had leukocytosis.

Cerebrospinal fluid (CSF) analysis showed elevated opening pressures (median, 30 and range, 21-42 cmH₂O), leukocytosis (median, 1,037.5 and range, 0-21,800 cells/ μ l), a high percentage of neutrophils (median, 77 and range, 0-99%), decreased sugar levels (median, 20.5 and range, 1-67 mg/dl) and increased protein levels (median, 173.5 and ranged, 75-290 mg/dl). These results are also consistent with previous reports (Lutticken *et al*, 1986; Arends and Zanen, 1988; Kay *et al*, 1995). All our patients had elevated open pressures, and all but one case, with associated septicemia, had leukocytosis of more than 350 cells/ml. The CSF leukocyte profile varied between neutrophilic (7, 58.3%) and lymphocytic (5, 41.7%) predominance. All except 3 patients, had decreased CSF sugar levels of less than 50 mg/dl, and all had increased protein levels of more than 45 mg/dl.

All *S. suis* isolates were sensitive to penicillin and cefotaxime with a median and range of MIC of 0.032, 0.025-0.064 and 0.064, 0.064-0.125 μ g/ml, respectively. This is consistent with other reports (Lutticken *et al*, 1986; Arends and Zanen, 1988; Kay *et al*, 1995). To date, there has been no report of penicillin-resistant *S. suis*. Thus, the therapy of choice for *S. suis* meningitis is penicillin.

The clinical outcomes were excellent for *S. suis* meningitis with a case fatality of 8.3%. The duration of defervescence after treatment was less than 7 days in all but 2 patients with sepsis and preexisting rheumatic heart disease. There was one relapse after initial treatment of only 8 days, followed by cure after a second course of treatment. The reason for the low case-fatality rate, which is consistent with most reports, may be due to the low prevalence of underlying diseases in most patients.

To date, there were 32 cases of *S. suis* meningitis (including ours) reported in Thailand (Phuapradit *et al*, 1987; Pootong *et al*, 1993; Leelarrasamee *et al*, 1997; Pumprueng and Pongvarin, 1997;

Paiboonpol, 1998; Chotmongkol *et al.*, 1999; Valaichone *et al.*, 2002). A summary of clinical features and the epidemiological data of these 32 cases is shown in Table 5. They are compared to 21 and 30 cases from Hong Kong (Kay *et al.*, 1995) and the Netherlands (Arends and Zanen, 1988), respectively. No significant epidemiological differences were observed between Thai, Hong Kong, and Dutch patients. Several parameters, including age, male preponderance, occupation, absence of underlying illness, and pig exposure, were similar. The relatively high median age (49, 53.7, and 49 years in Thai, Hong Kong, and the Dutch series), respectively and the male preponderance (23:9, 14:7, and 26:4) can be explained by the fact that *S. suis* meningitis is an occupational disease. In the Thai reports, there was one female patient who was only one month old (Vilaichone *et al.*, 2002). The percentage of history of pig exposure was highest in the series from Hong Kong (62%), followed by those in the Thais (28.1%), and the Dutch (9%) patients. The basis for this difference may be due in part to the fact that all 3 series were studied retrospectively, and thus underreporting in each series may be different. Most patients were butchers, pig farmers, meat transporters or laborers. No differences in percentage between the occupations was observed in the 3 series (65.4, 61.9 and 83.3%, respectively). A relatively high number of housewives was also noted, probably due to contact with contaminated pork during food preparation.

Most patients with *S. suis* meningitis were previously healthy. Underlying illness was observed in 31.8, 24, and 13% for the Thai, Hong Kong, and Dutch series, respectively. Our Thai series also documented a high percentage of patients with a history of alcohol consumption (88.2%). The actual percentage may be even higher due to the limitations of a retrospective study.

The interval from the onset of symptoms until admission to the hospital was not significantly different [mean: 4.5 and range: 1-14 days; 2.3 and 8 hours-10 days; 2 (median) and 1-8 days; in the Thai, Hong Kong, and Dutch series, respectively].

Most patients presented as acute meningitis within 2 weeks of the onset of symptoms. The associated extraneurological manifestations involved mostly skin and soft tissues, including arthritis, myositis, fasciitis, and cellulitis. There were significant numbers of skin and soft tissue

infections in the Thai and Hong Kong series (30.8 and 24%, respectively). Only 1 case (3.3%) was described in the Dutch series. This discrepancy between the Dutch series (representing European patients) and the Thai as well as the Hong Kong series (representing Asian patients) can not be explained by epidemiological differences. Four of 16 cases (25%) with arthritis were described in the UK (Hickling and Cormack, 1976; Shneerson *et al.*, 1980; Hay *et al.*, 1989; Twort, 1981; McNeil and Gordon, 1986; Agass *et al.*, 1997). Surprisingly, there was one case with toxic shock syndrome in our report. This syndrome was previously described in infections due to *Staphylococcus aureus*, β -hemolytic *Streptococcus pyogenes*, *Streptococcus agalactiae* and viridans group of Streptococci. Other associated manifestations are endophthalmitis (Agass *et al.*, 1997) and uveitis (Chau *et al.*, 1983).

Hearing loss and other eighth cranial nerve abnormalities, such as vestibular dysfunction, are the most common neurological complications of *S. suis* meningitis. The incidence was comparable between the 3 series: 68.8, 81, and 54% in the Thai, Hong Kong, and Dutch series, respectively. The onset of hearing loss was reported only in the Hong Kong series. It appeared between 1 and 12 days after admission. Other neurological complications included third cranial nerve palsy (2 cases, Thai series) and cerebritis/ventriculitis (1 case, Thai series) (data not shown) (Pootong *et al.*, 1993).

Complete blood counts were described only in our series. Most patients had leukocytosis (median: 19,835 and range: 5,590-47,300 cells/ μ l) and neutrophilia (median: 88% and range: 70-90%).

Cerebrospinal fluid (CSF) analysis was comparable among the 3 series. Most patients had CSF with high leukocytes (median: 925 and range: 0-21,800; 1285 and 4-10,720; 1,500 and 50-110,000 cells/ μ l), high percentage of neutrophils (65 and 0-99% in Thai series), low sugar levels (5 and 0-67; 7.2 and 1.82-79.2; 1.8-58.5 mg/dl), and high protein levels (176 and 75-456; 406 and 60-940; 300 and 80-980 mg/dl) in the Thai, Hong Kong and Dutch series, respectively. Opening pressures and positive CSF Gram staining were documented only in our series. The median and range were 33 and 14-50 cmH₂O, respectively. Only 18 of 30 (56%) of CSF specimens were positive for bacteria on Gram staining.

Only our series reported data of *in vitro* susceptibility tests for the isolates of *S. suis* to penicillin. All 32 isolates were sensitive. This correlated well with the favorable clinical outcome for most patients treated with penicillin and/or other β -lactam antibiotics. Rapid defervescence after treatment was described in our series. The median and range of defervescence were 5 and 2-14 days, respectively. The median and range of duration of treatment were 14 and 12-30 days as well as 1-6 weeks, in the Thai and Hong Kong series, respectively. The clinical outcome was excellent among the 3 series when compared to acute meningitis caused by other bacteria. The case fatality rates were 6.3, 4.8, and 6.7%, respectively.

In summary, we described 12 cases of *S. suis* meningitis at Chulalongkorn University Hospital and presented a comparative review of case reports of *S. suis* meningitis in Thailand, Hong Kong, and the Netherlands. The epidemiological and clinical clues for *S. suis* meningitis are summarized. Acute or subacute meningitis in adult patients should be suspected as being due to *S. suis* on the following grounds: patients with no preexisting illness, history of alcohol consumption, occupations related to pigs or pork, 1-to-14-day-course of meningitis, with or without associated skin and soft tissue infections, hearing loss or other eighth cranial nerve abnormalities, leukocytosis and neutrophilia, CSF with elevated opening pressures, leukocytosis, decreased sugar levels, increased protein levels and a neutrophilic or lymphocytic profile.

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